Virtual Technologies in Medicine

№1 (47) 2026

ISSN: 2686-7958
ISSN: 2687-0037

Published by the Russian Society for Simulation Education in Medicine, ROSOMED

CorView3DR, cardiac and great vessel interventions simulator

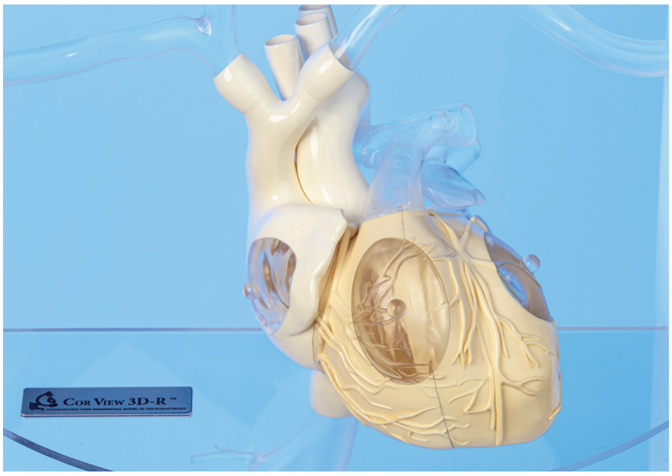
CorView3DR is the world's first radiodense heart & great vessels simulator for cardiovascular interventions.

CorView3DR realistically simulates the anatomical structures of the heart and great vessels of an adult, ostia of coronary arteries and coronary sinus of the heart are patent, interatrial septum in the area of the oval fossa is accessible for puncture.

Endocardium is made of the material enabling implantation of electrodes, vessels are hollow on the inside and have transparent walls for visual monitoring; walls of the heart chambers are provided with viewing ports (for visual check).

Intended Use

The **CorView3DR** simulator is designed for educating cardiovascular surgeons and practicing technical, tactile and practical skills in x-ray surgery, arrhythmology and interventional electrophysiology.



Key Features

- Imitation of tactile sensations experienced by a surgeon when manipulating a catheter inside the heart.
- Viewing ports enable monitoring the course of the surgery.
- Performing X-ray guided interventions in a Cath lab.
- Availability of various surgical access options that imitate native ones: the inferior vena cava, descending aorta, jugular veins, subclavian veins, subclavian arteries.
- Possibility of conducting, fixing and positioning diagnostic and ablation electrodes, implantable electrodes of pacemakers, cardioverter-defibrillators and devices for cardiac resynchronization therapy, as well as coronary guidewires and catheters.

VIRTUAL TECHNOLOGIES IN MEDICINE

No. 1 (47) 2026

SCIENTIFIC AND PRACTICAL JOURNAL
ON VIRTUAL AND SIMULATION TECHNOLOGIES IN MEDICAL EDUCATION
AND CLINICAL PRACTICE

Official publication of the All-Russian Public Organization
“Russian Society for Simulation Education in Medicine,” ROSOMED
www.rosomed.ru

V52
UDC 61:004(051)

The journal was founded in 2008

Frequency: quarterly (4 issues per year)
Certificate of Registration of a Mass Media Outlet
No. FS77-34673 dated December 23, 2008

Editor-in-Chief: Academician of the Russian Academy
of Sciences, Professor Valery Kubyshkin, MD

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Executive Secretary of the journal: Inna Sherer
Proofreading: Galina Yankovskaya
Computer typesetting and layout: Ludmila Vasilyeva
Original layout: ROSOMED Publishing House

Format: 210 x 297 mm
ISSN: 2686-7958 — print edition
ISSN: 2687-0037 — online edition

FOREWORD
FROM THE DEPUTY EDITOR-IN-CHIEF OF THE JOURNAL

The first issue of 2026 reflects the breadth of our journal's topics — from teaching practices in residency programs to the philosophy of the pedagogical calling.

The issue opens with a study by Alexander Andreenko, dedicated to a survey of residents and graduates in the specialty "anesthesiology and intensive care medicine." The survey (n = 291) showed that practical training does not allow for the confident mastery of all necessary practical skills for performing procedures and does not prepare graduates using simulation skills for independent action in various critical situations.

A team from Surgut State University presents the results of a pilot project on the use of artificial intelligence in teaching students introductory medical science. A combination of chatbots, virtual patients, and simulators has proven particularly effective in developing patient interview skills.

A review article by a team of authors from Moscow systematizes the possibilities of immersive technologies for people with disabilities. A SWOT analysis of the Russian VR market honestly identifies both the potential and the barriers — high cost, a shortage of content, and a lack of competent specialists.

Authors from Arkhangelsk Medical College share their experience with a regional competition using the "Pirogov" interactive anatomical complex. The experience has convincingly shown that students with practical experience using interactive equipment consistently outperform those limited to theoretical formats.

The issue concludes with a discussion article — a vivid manifesto against formalism in continuing professional education. Using the metaphor of cinema, the authors formulate a code and concept of a "teaching task force" in the field of medical education.

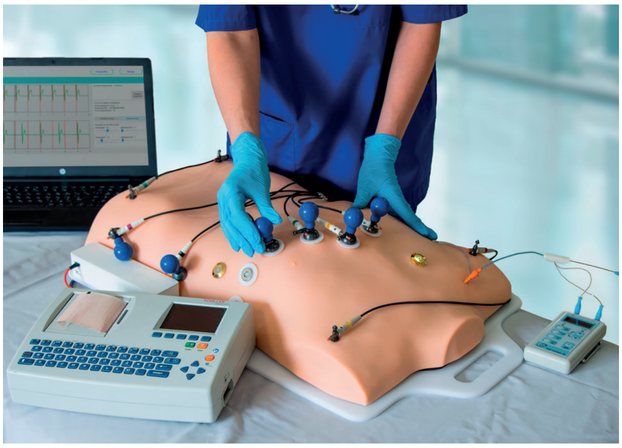
This issue brings together an honest look at the problems and concrete ideas for overcoming them. It is precisely this kind of dialogue that brings simulation-based education to life.

Maxim Gorshkov

Deputy Editor-in-Chief of the Journal
Prof.h.c., MD, Dipl.Econ., MMSim (Uni Graz)
Chairman of the ROSOMED Expert Committee
Director of the European Simulation Institute, EuroMedSim

CONTENT

CorView ECG, interactive ECG simulator



CorView ECG simulator allows to practice the skill of applying the electrodes for recording 12 ECG leads. It contains the anatomical landmarks necessary for positioning the electrodes and it simulates 120 different types of heart rhythm.

CorView ECG simulator allows to independently create and reproduce a virtual ECG, it contains a plug-in module for temporary cardiac pacing (ECP) with the ability to program an external pacemaker.

CorView ECG simulator is designed to practice the skills of examining a cardiac patient and can be used for accreditation in the specialties of "General Medicine" and "Pediatrics" as well as in the station - "Diagnostics of the cardiovascular system".

Key Features

- Realistic tactile sensations;
- Anatomical landmarks for applying ECG electrodes;
- Temporary cardiac stimulation module;
- Defibrillation capability;
- The ability to independently create and reproduce any heart rhythms for temporary cardiac stimulation.

Skills to train

- Application of electrodes in accordance with anatomical landmarks;
- Registration of 12 ECG leads: 120 different types of heart rhythm;
- Cardioversion using a defibrillator;
- Conducting temporary electrical stimulation with the ability to program an external pacemaker in real time.

The 15th Anniversary Congress of the Russian Society for Simulation Education in Medicine and the International Conference "Simulation-Based Medical Education: Experience, Development, Innovation. ROSOMED–2026 is Russia's most authoritative scientific and practical event in the field of medical simulation, with a long history and tradition. Every year, hundreds of experts from Russia, Belarus, Central Asia, the South Caucasus, and other countries gather to discuss practical experience and the prospects for the development of simulation technologies.

The conference, held with the support of the Ministry of Health of the Russian Federation, is organized by the Russian Society for Simulation Education in Medicine (ROSOMED) and the Russian Medical Association (RMA).

This year, the event will take place at the Holiday Inn Sokolniki Hotel's convention center — the venue where, in 2018, the country's first open public piloting of OSCE stations was held, organized by ROSOMED, which marked the beginning of the introduction of simulation methods into the accreditation system for medical specialists in Russia.

Actual information about the event, registration, and abstract submission is available at rosomed.ru

Venue: Hotel "Holiday Inn Sokolniki", Moscow, 24 Rusakovskaya St. ("Sokolniki" Metro Station)

Dates: October 7–8, 2026

We invite you to ROSOMED-2026!

VI All-Russian Olympiad in Internal Medicine with International Participation, 2026. Organizer: I.I. Mechnikov North-Western State Medical University, in co-operation with ROSOMED. More than a thousand students from various countries — ranging from vocational school students to graduates — will compete in Russian or English in an online format. More: rosomed.ru/conferences/229

International Scientific and Practical Conference “Simulation-Based Education in Medicine: Problems, Solutions, Prospects” will take place on November 17, 2026, at the Andijan State Medical Institute, Andijan, Republic of Uzbekistan. For details, see the website: rosomed.ru/conferences/232

The world’s largest conference on simulation-based education, IMSH, will take place in New Orleans, USA, January 23–27, 2027. Five days packed with hands-on workshops, master classes. The event, presentations by experts from around the world, will bring together several thousand professionals and more than 130 leading manufacturers in the field of medical simulation. Registration will open in the fall of 2026. For more information: imsh2027.org

The 2026 annual conference of the European Society for Simulation in Medicine (SESAM) will be held in Lyon from June 17–19, 2026. As a point of reference, last year’s conference was attended by over 1,400 participants from 65 countries, and the program featured 487 presentations and 83 workshops. For more information please visit web-site www.sesam-web.org

PRACTICAL TRAINING IN THE RESIDENCY PROGRAM IN ANESTHESIOLOGY AND INTENSIVE CARE USING SIMULATION-BASED EDUCATIONAL TECHNOLOGIES — RESULTS OF AN ANONYMOUS SURVEY OF RESIDENTS AND 2025 RESIDENCY GRADUATES

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DOI: 10.46594/2687-0037_2026_1_2155

Abstract. To study the subjective assessment and satisfaction with the organization of practical training during education using simulation-based educational technologies, an anonymous online survey (22 questions) was conducted among students and graduates of the 2022–2025 clinical residency program. A total of 291 responses were received. The results of the study revealed a lack of a systematic approach to teaching practical skills and limited training on procedures for handling critical situations. A significant portion of respondents indicated incomplete mastery of procedures during training, a lack of theoretical and practical training in the residency program, and, consequently, doubts about their readiness to act in critical situations. Thus, according to the survey data, practical training during residency in anesthesiology and critical care does not fully ensure confident mastery of practical skills for performing procedures or prepare graduates, using simulation technologies, for independent work in various critical situations.

Keywords: simulation training in anesthesiology and critical care medicine, practical training in residency, online survey, critical situations.

Conflict of interest. The author declares no conflict of interest.
The author declares that he is a member of the editorial board of the journal "Virtual Technologies in Medicine." The manuscript underwent the standard independent peer-review procedure , and the decision to publish was made independently of the author.

For citation: Andreenko A. A. Practical training in the residency program in "Anesthesiology and Resuscitation" using simulation-based educational technologies — results of an anonymous survey of residents and 2025 residency graduates // Virtual Technologies in Medicine. 2026. No. 1. Pp. 8–13. DOI: 10.46594/2687-0037_2026_1_2155

Scientific specialty: 3.1.12. Anesthesiology and Resuscitation; 3.2.3. Public Health and Health Care Organization, Sociology and History of Medicine

Received by the editorial office on January 4, 2026 .
Received after peer review on February 13, 2026
Accepted for publication on February 13, 2026

Relevance

The readiness of residents in the specialty of "anesthesiology and intensive care" for future clinical practice is determined by the level of theoretical knowledge acquired, the confident mastery of practical skills, and the acquisition of so-called non-technical skills. The level of practical training of residency program graduates can be assessed through the initial specialized accreditation process, 360-degree workplace evaluations, and employer performance reviews over a specific time period. Feedback from students and residency program graduates is also one of the methods for obtaining information about the training process and outcomes. Surveys of residents currently being conducted at universities across the country focus on assessing student satisfaction with general aspects of the educational process and do not evaluate in detail the quality of practical training or the role of simulation technologies during training [2; 3]. At the same time, numerous studies have demonstrated that the effective use of simulation-based educational technologies, given the limited opportunities to acquire skills while working with real patients, is a crucial factor in shaping young professionals who are ready for real-world practice.

Research Objective

To analyze the subjective assessment and satisfaction of students and graduates of the 2022–2025 clinical residency program regarding the organization of practical training during their studies using simulation-based educational technologies in the educational process at universities in our country.

Materials and Methods
A research group comprising experts from the Federation of Anesthesiologists and Resuscitators (FAR), the Association of Anesthesiologists and Resuscitators (AAR), and Rosomed developed a 22-question survey. The questions were directed at medical school graduates currently undergoing residency training in anesthesiology and intensive care, as well as graduates of the 2022–2025 residency programs. The organization of practical training, teaching methods, and the list of practical skills mastered using simulation equipment were also analyzed. The organization of the system for assessing the mastery of practical skills, its methodology, and forms were examined. Particular attention was paid to training residents in actions during critical situations in anesthesia and intensive care using highly realistic simulation equipment. Mastering these "non-technical skills" is extremely important for the future clinical practice of anesthesiologists and intensivists. Some of the questions were addressed to residents who had completed their residency and concerned their self-assessment of their level of mastery of practical skills, their readiness to act independently in critical situations, as well as their overall satisfaction with the level of their practical training upon completion of their residency.

An anonymous online questionnaire was developed for the study in the form of a Google Form titled "Practical Training in the Residency Program in Anesthesiology and Intensive Care" (URL: https://docs.google.com/forms/d/e/1FAIpQLSfiQWzsWd050nl7Mc9lc2G5Zn-R_om5YVCmiPaKXSOrxFebxw/viewform?usp=header), which was distributed on various platforms and sent to relevant departments.

Results
A total of 291 responses were received. Among the respondents were 75 (25.8%) first-year residents, 90 (30.9%) second-year residents, and 126 (43.3%) residents who graduated between 2022 and 2025. A total of 291 respondents.

In response to the question "Did you visit the simulation center during your training?", the following answers were received: nearly 15% of respondents answered "never," and this group included both residents and graduates. Additionally, 9.3% of respondents (exclusively graduates and second-year residents) indicated that they visited the simulation center "only to practice skills as part of preparation for accreditation." Thirty-seven percent of respondents reported having regular scheduled sessions, while 39% indicated that they had participated in occasional sessions focused on specific skills (no more than five per year). By comparison, a survey of residents in Romania indicated an average frequency of visiting simulation centers one to three times a month during the first two years of residency [7].

As we can see, only 37% of respondents indicated that, when learning practical skills, they first received theoretical material in the form of lectures, videos, etc., and then, under the guidance of instructors in simulation centers, practiced procedures on manikins and took a test to assess their acquired skills. 22% of respondents indicated that, after receiving theoretical material, they participated in sessions at simulation centers to practice specific practical skills without any assessment of their mastery. 28% of respondents indicated that no training in procedures was conducted at a simulation center, and skills were practiced in hospital settings on real patients. 58% of respondents received initial theoretical information on the techniques for performing procedures from instructors; additionally, 75% independently studied printed sources, and 94% of respondents studied electronic materials. Notably, 5% did not use any theoretical materials for preliminary study of the techniques for performing procedures. When asked "who conducted the sessions at the simulation center," 76% answered "a department instructor," 35% indicated sessions led by simulation center staff, and 31% practiced independently.

An important aspect was the detailed identification of the list of procedures that residents had previously mastered in the simulation center using manikins, as well as a comparison with procedures performed for the first time on actual patients without prior practice on manikins (Table 1). It is noteworthy that even the basic skills of an anesthesiologist-resuscitator were initially practiced in the simulation center on manikins by far from all residents, and the percentage of procedures performed for the first time on real patients without prior practice on manikins remains quite high.

Table 1

List of procedures practiced on manikins and initially performed on real patients

No.	Practical skills	Practical skills that respondents practiced on manikins in the simulation center under the guidance of an instructor (%)	Practical skills that respondents performed for the first time on real patients without prior practice on manikins in the simulation center (%)
1.	Placement of nasopharyngeal and oropharyngeal airways	59%	40
2.	Performing the Safar triple maneuver	51%	49%
3.	Ventilation via face mask	53%	46%
4.	Direct laryngoscopy and tracheal intubation	70%	30%
5.	Indirect laryngoscopy and tracheal intubation	35%	28%
6.	Placement of supraglottic airways	51%	47%
7.	Flexible endoscopy and tracheal intubation	20%	16%
8.	Surgical cricothyroidotomy	30%	2%
9.	Pleural puncture and drainage	14%	2%
10.	Subarachnoid space puncture	43%	39%
11.	Epidural puncture and catheterization	42%	39%
12.	Central venous catheterization using anatomical landmarks	58%	41%
13.	Central venous catheterization with ultrasound guidance	42%	46%
14.	Arterial puncture and catheterization	4%	66%
15.	Performing ultrasound protocols for the assessment of critically ill patients	17%	32%
16.	Performing a set of basic resuscitation procedures	71%	28%
17.	Performing a set of advanced resuscitation procedures	71%	25%

The survey examined the system for assessing skill mastery during the training process. It should be noted that 49% of respondents indicated the absence of any assessment measures to evaluate skill mastery after training; 11% indicated that they took the practical skills assessment without instructors using checklists; 40% of respondents took the practical skills assessment using checklists.

Another question regarding residents' self-assessment of their mastery of practical skills was: "From the list of procedures below, please indicate those which, in your opinion, you did not master sufficiently during your residency training." Overall, respondents indicated a confident mastery of basic skills for maintaining upper airway patency, direct laryngoscopy and tracheal intubation, performing a range of resuscitation procedures, and techniques for neuraxial anesthesia (subarachnoid space puncture). At the same time, the level of proficiency in important modern techniques remains low. For example, 57% of graduates indicated a lack of confidence in performing flexible airway endoscopy and tracheal intubation using a flexible endoscope, even though this skill is mandatory under professional standards. Thirty-five percent of residency program graduates doubt their readiness to effectively use video laryngoscopes. Similarly, 69% of respondents indicated they were unprepared to perform emergency surgical cricothyroidotomy. 31% consider themselves unprepared to perform epidural puncture and catheterization; 22% of graduates, in their opinion, have not mastered the skill of arterial puncture and catheterization; 16.5% of graduates considered their proficiency in performing ultrasound-guided central venous puncture and catheterization to be insufficient; 50% of respondents consider themselves unprepared to perform bedside ultrasound examination protocols.

An important focus of training for anesthesiology-resuscitation residents is the teaching of "non-technical skills," as well as the ability to act in critical situations using the concept of "resource management in critical situations." Mastery of these skills determines an anesthesiologist-resuscitator's ability to prevent, predict, recognize, and resolve critical situations during anesthesia and intensive care. Unfortunately, the survey results confirmed the current situation, in which these issues are not addressed by all departments during training and are not covered systematically, while expensive, highly realistic equipment is used inefficiently. Only 37% of respondents attended lectures on actions during critical situations, while 28% of those surveyed studied this topic independently. Instructors covered action algorithms for specific situations in lectures for 49% of respondents; 31% of respondents studied materials on this topic independently, either without lectures or in addition to them. Classes using highly realistic patient simulation robots to practice action algorithms were conducted with 53% of respondents.

Among the topics most frequently practiced using patient simulation robots, respondents cited: induction of elective anesthesia (56%), induction of emergency anesthesia (48%), “difficult airway” situations (56%), complications of general anesthesia (41%), hemodynamic disturbances (27%), respiratory problems during anesthesia (31%), and techniques of inhalation anesthesia (16%). Only 5% of respondents practiced managing complications of regional anesthesia, and 13% practiced anesthesia for severe trauma.

Generally similar topics (“difficult airways,” anesthesia for multiple trauma, advanced cardiopulmonary resuscitation) were most frequently practiced during resident training in various European countries, as demonstrated by a group of authors in a survey of 268 residents from 37 European countries [4]. Residents in Romania provided similar responses regarding the importance of including the topics listed above. At the same time, the surveyed residents indicated that simulation training improves their knowledge, communication skills, and ability to work in a team [7]. Interdisciplinary training on highly realistic robotic simulators was conducted with only 22% of respondents.

An objective assessment of trainees’ ability to act independently in various critical situations is an important element of the educational process. It provides an opportunity for feedback, analysis of one’s actions, and correction of identified errors. Only 41% of respondents indicated that their actions during simulated scenarios were evaluated by instructors. Only 38% of respondents underwent an evaluation of their actions while working with robotic simulators during the practical portion of their exams.

The comprehensive self-assessment of residency program graduates regarding their readiness for independent practice and their final opinion on the level of their practical training during their studies are also of great interest. The overall assessment of graduates’ satisfaction with the level of practical training regarding the mastery of procedures yielded the following results: fully satisfied—nearly 26% of respondents; partially satisfied—51%; somewhat dissatisfied—13%; and completely dissatisfied—10%. Graduates’ assessment of their readiness to perform procedures upon completion of their studies showed that 17% of the surveyed graduates consider themselves confident in performing procedures; 50% have confidently mastered the basic procedures; 27% generally possess all the basic skills but periodically experience difficulties; 6% are unsure of their skills and regularly experience difficulties when working independently. Self-assessment of readiness to act independently during critical situations is an important issue. 29% of graduates considered themselves fully prepared to act during most critical situations. 61% of respondents considered themselves somewhat prepared to act in most critical situations; 7% considered themselves somewhat unprepared to act during critical situations; and 3% considered themselves completely unprepared for such situations.

The authors conducted an additional comparative analysis of the structure of responses from graduates of different years to assess possible trends in simulation training over the past five years. A comparison of the responses revealed no significant difference in the frequency of specific response options among graduates. Given the limited sample size, the results suggest that there have been no significant changes in the practical training of anesthesiology-resuscitation residents.

Discussion

Conducting surveys of residents regarding their experience with simulation-based training, identifying the positive and negative aspects of this experience according to respondents, and gathering their suggestions and wishes for improving the educational process is a fairly standard procedure. Surveys of this kind have been conducted among anesthesiology residents in Canada [5] and Romania [7], and pan-European studies have also been organized [4]. Taking into account the available data from the above-mentioned surveys, we were interested in analyzing the results obtained, identifying the reasons behind the respondents’ answers, attempting to assess the situation regarding practical training in the residency program in anesthesiology and critical care using simulation technologies as a whole, and comparing our data with international findings.

We found that nearly 15% of respondents (residents and graduates) answered “never” to the question “Did you visit a simulation center during your training?” Additionally, 9.3% of respondents (graduates and second-year residents) indicated that they visited the simulation center “only to practice skills as part of preparation for accreditation.” At the same time, only 37% of respondents mentioned regular scheduled classes, while 39% indicated that they had attended occasional sessions focused on specific skills. These figures indicate a persistently unsystematic approach to teaching residents practical skills and the ability to act in various clinical situations. There also remains a completely methodologically flawed practice of so-called “cramming” residents to pass the second stage of the upcoming primary specialized accreditation, rather than providing consistent, systematic training.

Only 37% of respondents described a full cycle of practical skills training (initial coverage of theoretical material through lectures, videos, etc., followed by practice on manikins under the guidance of instructors in simulation centers, and a skills assessment to verify mastery); 22% of respondents completed nearly the entire training cycle without taking an assessment or having their skill mastery evaluated, which reduces the effectiveness of training; 28% of respondents indicated that training in procedures was not conducted in a simulation center and that skills were practiced in hospital settings on real patients. Such a high percentage of residents who did not receive initial training in the safe performance of procedures on manikins and were allowed to treat real patients represents a serious violation of safety protocols in anesthesiology and intensive care and carries a high potential risk of complications.

It was also important for the survey authors to obtain comparative data on the set of practical skills initially mastered in simulation centers using manikins, and those procedures that residency graduates performed for the first time directly on patients without prior training during their residency. Analysis of the data in Table 1 revealed an overall unsatisfactory situation. The very fact that a number of procedures were initially performed on real patients without prior training on manikins during residency training does not meet modern requirements for safe clinical practice. Thus, even basic upper airway management skills (lines 1–4, 6) were mastered in the simulation center in only 50–70% of cases. Modern methods of upper airway management, the performance of which is specified in the professional standard for anesthesiologists and intensivists (use of flexible endoscopy, video laryngoscopes, and cricothyroidotomy), were mastered to a very limited extent during residency training (no more than 30% of respondents answered affirmatively). The data on residency training in basic and advanced resuscitation protocols, neuraxial anesthesia, and central venous catheterization using anatomical landmarks and ultrasound guidance are somewhat surprising. Since the responses were provided by graduates, and the aforementioned skills are part of the stations in the second stage of primary specialized accreditation, the data raise questions regarding both the organization of training and preparation for accreditation.

When examining the list of skills that graduates, in their opinion, had not mastered with sufficient confidence upon completion of residency, it is noteworthy that almost all respondents considered themselves proficient in the basic skills of maintaining upper airway patency , direct laryngoscopy and tracheal intubation, performing a complex of resuscitation measures, and methods of neuraxial anesthesia (subarachnoid space puncture). However, a significant proportion of graduates are not confident in their mastery of modern skills, and this applies to such important procedures and competencies as performing flexible airway endoscopy and tracheal intubation using a flexible endoscope, central venous catheterization with ultrasound guidance, the use of video laryngoscopes, performing emergency cricothyrotomy, and performing bedside ultrasound examination protocols. Taken together, this suggests that departments pay little attention to training in modern techniques specified in professional standards, which have already been incorporated into actual clinical practice and are critically important from the perspective of patient safety.

The above conclusion was confirmed by an analysis of information regarding the inclusion of training on critical situations in anesthesiology and resuscitation within the educational curriculum. Training in "non-technical skills" and responding to critical situations in accordance with the concept of resource management during crises is conducted in only a limited number of universities and in a non-systematic manner, while expensive, highly realistic equipment is used inefficiently. Only 37% of respondents had attended lectures on actions during critical situations, and 49% of those surveyed reported that instructors covered action algorithms for specific situations in their lectures. Classes using highly realistic patient simulation robots to practice action algorithms were conducted with 53% of respondents. The list of clinical situations practiced using patient simulation robots is generally similar to that reported in other surveys. However, even standard topics and critical situations were studied in only half or fewer of the cases.

Thus, it can be concluded that at least half of the residents and graduates did not have the opportunity to acquire theoretical knowledge and practice skills for responding to critical situations in safe simulated conditions. The low frequency of performance evaluations of respondents during simulated scenarios is also a factor that reduces overall patient safety due to the likelihood of ineffective actions by anesthesiologists and intensivists. The need for more frequent training on critical situations and interdisciplinary training was expressed by residents in Canada in a 2010 survey [5]. Residents surveyed in a study by S. Shailaja et al. [6] described highly realistic simulation sessions positively, noting the presence of moderate stress during sessions, which ultimately increased motivation and a sense of responsibility.

The results of the final self-assessment by residency program graduates regarding their readiness for independent practice and their opinions on the level of practical training during their education showed the following: nearly 77% of respondents were fully or partially satisfied with the level of practical training; nearly 67% had confidently or generally mastered the basic procedures. At the same time, 33% of respondents feel uncertain and experience occasional or regular difficulties when performing procedures. 29% of graduates considered themselves fully prepared to act during the development of most critical situations, while 61% of respondents felt somewhat prepared to act in most critical situations. These figures raise certain questions and may indicate some overestimation of respondents' self-assessment, given that training on critical situations was conducted with only 53% of those surveyed.

Limitations of the study

In organizing an anonymous online survey, the authors took into account all the advantages and limitations inherent in this method [1]. This survey design allowed us to collect data remotely, at a time convenient for respondents, without regional restrictions, and within a limited timeframe, while the anonymous nature of the survey potentially increases the objectivity of the responses.

One of the potential drawbacks of online surveys is sample bias and the potential for skewed responses. Undoubtedly, our study is not entirely free of these shortcomings. It is clear that we received responses from students and graduates of far from all universities in the country. Additionally, responses to some questions on the same topic, but specifically phrased differently, indicate a certain degree of inattention and inaccuracy when filling out the questionnaire. In this regard, we compared the results obtained with published data from previous studies conducted abroad. Overall, they were comparable, which ultimately allows us to consider the results of our work to be valid and representative.

Conclusion

The results of this study suggest that, despite the availability of material resources, human resources, and the existing system of primary specialized accreditation, practical training in the residency program in anesthesiology and intensive care does not ensure the confident mastery of all necessary practical skills for performing procedures and, equally important, does not prepare graduates, using simulation technologies, for independent work in various critical situations. Furthermore, the study's findings suggest that, due to a combination of well-known and as-yet-unresolved issues, expensive, highly realistic equipment is not being fully utilized in educational institutions, which also reduces graduates' readiness for independent clinical practice.

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METHODS FOR APPLYING ARTIFICIAL INTELLIGENCE IN THE EDUCATIONAL PROCESS OF A MEDICAL UNIVERSITY

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DOI: 10.46594/2687-0037_2026_1_2149

Abstract. This article presents the results of a descriptive pilot project titled “Intelligent System for Teaching Basic Clinical Examination Skills.” The project investigated the application of publicly available artificial intelligence in the educational process at a medical university. The study included 58 third-year students from Surgut State University majoring in “General Medicine,” from whom two comparison groups were randomly formed—the study’s group, in which the AI-based training technology was tested (n = 29), and a control group consisting of students trained using traditional methods without artificial intelligence (n = 29). As a result of the project, a methodology was developed for problem-based, competency-based, self-directed learning of basic clinical examination skills using simulators, virtual patients, and artificial intelligence. No negative results were observed during the testing of artificial intelligence in the educational process of a medical school. The combination of simulators, virtual patients, and artificial intelligence proved most effective in developing and refining communication skills in the “doctor-patient” system within a simulated environment.

Keywords: artificial intelligence, virtual patient, propaedeutics of internal medicine.
Funding. This project was carried out with grant support from the Russian Society for Simulation-Based Medical Education, a nationwide public organization, in 2025.
Conflict of Interest. The authors declare no conflict of interest.
Citation: Graudina V. E., Kushnikova I. P., Shchelnikova A. S. Methods for the Application of Artificial Intelligence // Virtual Technologies in Medicine. 2026. No. 1. Pp. 14–21. DOI: 10.46594/2687-0037_2026_1_2149
Scientific specialty: 3.2.3. Public Health and Health Care Organization, Sociology and History of Medicine

Received by the editorial office on November 21, 2025
Received after peer review on December 11, 2025
Accepted for publication on February 24, 2026

Introduction

In the fall of 2019, a Presidential Decree of the Russian Federation approved the National Strategy for the Development of Artificial Intelligence for the period up to 2030 (hereinafter referred to as the Strategy), which emphasized the importance and necessity of applying artificial intelligence (AI) in education [2]. New scientific and technical products utilizing AI must be developed through high-quality research activities [1]. Currently, the initial experience of using AI models in the higher education system has been accumulated and analyzed, with the risks of its application identified [4]. It is critically important to ensure a unified approach to determining options for the use of artificial intelligence technologies in research activities in education [3].

Modern medical education requires future specialists to master professional, personal, and organizational competencies to the level of skills through the study of a vast amount of information during their training. For today’s Generation Z students, education without the use of new learning technologies becomes ineffective [5]. It is strategically important to develop new teaching methods, including those utilizing AI, that ensure the acquisition of accurate, scientifically validated specialized knowledge. At the same time, there are currently insufficiently tested methods for using publicly available AI in the study of disciplines in medical education, including its integrated application in conjunction with simulators.

Research Objective

To develop, test, and evaluate the effectiveness of a problem-based, self-directed learning methodology with integrated artificial intelligence technology in the educational process of a medical school.

Research objectives:
To develop a methodology for problem-based, competency-based, self-directed learning of basic clinical examination skills using simulators, virtual patients, and artificial intelligence (hereinafter referred to as the Methodology);
1) to test the developed Methodology, establishing its expert and content validity;
2) to evaluate the effectiveness of the combination of simulators, virtual patients, and artificial intelligence.

Materials and Methods

This study is a descriptive pilot project on the application of publicly available AI in the educational process at a medical university, using the teaching of the course "Propaedeutics of Internal Medicine" as a case study. The study was conducted in two groups: 1) the experimental group (EG), in which the AI technology was tested (n = 29), 2) the control group (CG), which included students taught using traditional methods, without the use of AI (n = 29). The study included third-year students at Surgut State University (SurSU) majoring in "General Medicine." Assignment to the EG or CG was conducted randomly.

Prior to the study, participants in the EG signed a voluntary informed consent form to participate in the study, including consent for photography and videography, as well as the publication of photographs.

The course "Propaedeutics of Internal Medicine" is taught in accordance with the curriculum of the Medical Institute (MI) of SurSU over the course of one academic year. In the fall semester, students study methods of clinical examination of patients, symptoms, and syndromes of internal organ system disorders, and in the spring semester — diseases of internal organ systems.

The practical component of the study lasted four weeks, during which the section "Diseases of the Digestive System" was covered as part of the "Propaedeutics of Internal Medicine" curriculum. Two in-person lectures and four classroom-based practical sessions were scheduled for the study of the "Diseases of the Digestive System" section. Independent student preparation at the Medical Institute of SurSU was managed using the Modular Object-Oriented Dynamic Learning Environment (Moodle) or a learning management system (LMS).

Two Moodle courses were created for the study: one for EG and one for CG (Fig. 1).

SurSU LMS

Moodle course for EG	Moodle course for CG
• Test to assess the baseline level of preparation (entrance test); • Instructions for studying the topic; • Slides from the lecture presentation on the topic; • List of case studies from the RUMEDIUS digital medical education system for completing practical assignments to review previously studied material on the topics*; • List of case studies from the RUMEDIUS digital medical education system for completing practical assignments to test newly learned material on the topics**; • List of sample prompts for interacting with AI: · to assess mastery of the theoretical material covered in the lecture; · for the purpose of conducting a debriefing on reports of completed practical assignments to review previously studied material on the topics*; · for the purpose of conducting a debriefing on reports of completed practical assignments to assess newly studied material on topics**; • Test to assess the section studied (final assessment)	• Test to assess the baseline level of preparation (entrance test); • Instructions for studying the topic; • Slides from the lecture presentation on the topic; • Set of clinical problems for completing practical assignments for the purpose of: · review previously studied material on the topics*; · to test newly studied material on the topics**. • List of questions for self-assessment: · to test understanding of the theoretical material covered in the lecture; · to check understanding of previously studied material on the topics*; · to assess mastery of new material by topic**. • Test to assess the section studied (final assessment)

* — In this course, previously studied material included a review of theoretical material on symptoms and syndromes of digestive system disorders in accordance with the syllabus for the course "Propaedeutics of Internal Medicine" at SurSU.

** — This course uses clinical cases for the diagnosis and treatment of diseases of the digestive system in accordance with the syllabus for the course "Propaedeutics of Internal Medicine" at the Medical Institute of SurSU.

Fig. 1. Structure of courses for independent student work on the SurSU LMS platform

The courses were identical in structure (pre-test, instructions for studying the topic, lecture slides on the topics, assignments for independent practical training, post-test). The pre-test and post-test for both groups consisted of 20 questions each, identical in terms of difficulty level.

The difference between the courses lay in the assignments for independent practical training and the specific features of the assessment tools used for these assignments. Independent work by GI students was conducted through interaction with AI, including within the RUMEDIUS digital medical education system. Lecture materials and presentations served as the basis for independent theoretical training. Clinical cases from the RUMEDIUS digital medical education system on the topics being studied served as the basis for independent practical training.

Independent work by medical students was conducted traditionally using a list of questions and standard clinical case studies.

The use of AI in this study included conducting an introductory interactive lecture on the process of interacting with neural networks, a list of standard prompts to assess students' self-preparation on theoretical material, and a list of standard prompts for conducting AI-assisted debriefings based on reports of completed practical assignments in the RUMEDIUS digital medical education system. To prevent the generation of incorrect information, training was limited to specific educational literature.

Monitoring of homework completion was also conducted via the SurSU LMS platform: students submitted the results of their debriefings with the AI to the course instructor by the assignment deadlines. Assessment of students' knowledge, skills, and competencies regarding the section and topics covered was conducted during in-class practical sessions. The structure of the in-class session for the final exam included a discussion of issues that caused difficulties during independent study of the topics and during interaction with the AI, as well as the resolution of clinical cases from the RUMEDIUS digital medical education system — interaction with a virtual patient, and the practice of clinical examination skills of the digestive system using a human head model (oral cavity examination technique) and the LivePalp® virtual palpation simulator (examination, palpation, and percussion techniques).

To gather feedback from EG students on the use of AI for learning one week after the study concluded, including after the final assessment on the topics studied, they were invited to complete an anonymous survey.

At all stages of the study, EG students received technical support for working with AI and the virtual patient via a specially created Telegram channel. To analyze the study results, we compared the scores from the initial and final tests, calculating indicators of academic performance, knowledge quality, and learning outcomes:

- academic performance = (number of "5" grades + number of "4" grades + number of "3" grades) × 100% / total number of students;
- quality of knowledge = (number of "5"s + number of "4"s) × 100% / total number of students;
- Academic proficiency is calculated using the formula "Students' Academic Proficiency Level" (SAPL) as: (number of "5"s × 100 + number of "4"s × 64 + number of "3"s × 36 + number of "2"s × 16 + number of "N/G"s × 7) / total number of students, where "N/G" refers to students not graded due to an unexcused absence.

An excellent test result ("5") was defined as 90% or more correct answers, a good result ("4") as 80–89% correct answers, a satisfactory result ("3") as 70–79% correct answers, and an unsatisfactory result as less than 70%.

Intergroup differences in qualitative characteristics were determined using Fisher's exact test (φ*-test). A p-value of < 0.05 was considered statistically significant.

Results and Discussion

The use of virtual technologies and the application of AI in medical education are established facts [4]. Regardless of the attitude of educators at any level of training toward the capabilities of AI, virtual reality (VR), and augmented reality (AR) and their application in the educational process, students are already using them. It is every teacher's responsibility to guide students at all stages of interaction with AI to prevent the formation of incorrect knowledge, skills, and abilities. Modern higher education must lead the way in the use of AI and ensure its competent application in educational and professional activities [8]. Thus, to address the first objective of this study, a Methodology for the Application of AI in the Educational Process was developed, comprising the following components:

1) preliminary training in the use of publicly available LLM (Large Language Model) chatbots and the basics of prompting;
2) the use of LLMs to test theoretical knowledge based on clearly defined prompts;
3) solving virtual clinical cases in the RUMEDIUS digital medical education system with integrated AI;
4) conducting debriefings using an LLM based on reports of virtual clinical case solutions within the RUMEDIUS digital medical education system.

The basics of prompting for EG students were presented during an interactive lecture, where the instructor explained the technology's principles and the process of interacting with LLMs. A large language model is a type of AI trained on massive datasets to understand and generate human language. Under the lecturer's guidance, the students tried using various chatbots themselves and gained an understanding of the possibilities of AI for independent preparation for practical classes (Fig. 2).

Students were offered a selection of chatbots using neural networks and available in the Russian Federation: YandexGPT (URL; https://ya.ru/ai/gpt), Giga.chat (URL; https://giga.chat), DeepSeek (URL: https://chat.deepseek.com), Mistral AI (URL: https://chat.mistral.ai/chat), Open GPT (URL; https://gpt-open.ru).

On the SurSU LMS platform, to assess self-study of theoretical material for the course "Propaedeutics of Internal Diseases" and its section "Diseases of the Digestive System," students were provided with an algorithm for interacting with AI. The algorithm included a list of standard prompts—requests to the bot—formed according to specific rules (Fig. 3).

Students could also enter any prompts if they needed for a deeper understanding of certain issues or if they encountered difficulties in comprehending the material.

Independent practical training for students was conducted using the RUMEDIUS digital medical education system (hereinafter referred to as the System). The System is a software and hardware platform for medical education in both in-person (classroom) and distance learning formats, designed to develop clinical reasoning and hone

Fig. 2. Introductory interactive lecture on how to use artificial intelligence

Get started with AI.
Test your theoretical knowledge.
Enter the first prompt at the beginning of the conversation:

Hello. Take on the role of a medical school professor.
Study the attached lecture and test my knowledge of the topic.
Come up with ten questions of varying difficulty based on the lecture material.
Ask me one question at a time, and I will answer them on my own.
If the answer is incorrect, suggest that I go back to the part of the lecture that contains the answer.
Stay within the scope of the lecture.

Attach the lecture in PDF format so the AI can ask you questions. Press Enter: the conversation has begun.
Answer each question based on what you remember from the material. Send your answer to the chatbot and wait for the AI's feedback.
Then ask it to continue with the next question.

When the AI has asked all the questions, type the second prompt in the chat:

Thank you.
You did a good job. Rate my answers on a scale of 1 to 5.

The AI will grade your answers.

Next type the third prompt in the chat:

What are my weak points, and what should I do to improve my score?

You receive an AI response that points out sections you can review further in the lecture or textbook.

For an in-depth study of the topic or to get explanations for unclear or complex questions, ask the AI this prompt:

«Imagine you are a medical school professor and explain this to me in simple terms… (Your question).»
Take on the role of an expert and explain to a medical school student … (Your question).

Fig. 3. Algorithm for interacting with AI to study theoretical material

practical medical skills and competencies using virtual simulation technologies.

For the course section “Diseases of the Digestive System,” students were offered lessons to review material on methods of examining the digestive system and the semiotics of its pathology. Relevant clinical cases were provided for studying the diseases. After completing each case, a report on the quality of the task’s completion was generated for the student. Based on the reports of completed practical assignments in the RUMEDIUS digital medical education system, students were tasked with conducting a debriefing using AI. A specific algorithm was developed for the AI debriefing (Fig. 4).

Debriefing with AI.
Test your practical skills.

After completing the case study, you will receive a report in PDF format.
To analyze the case, you need to create a new chat and upload your report to the AI.

Enter the following prompt at the beginning of the conversation:

Hello.
Take on the role of a medical school professor.
Analyze the report on the clinical case and provide feedback,
What are the strengths and weaknesses?
Suggest what to focus on to improve the results.

Fig. 4. Algorithm for interacting with AI for conducting a debriefing on a clinical case

Thus, the interaction process allowed for personalizing information for each student, creating questions to test their understanding of the material, and receiving feedback based on their answers. Students independently chose a chat they found convenient to use and could expand their query during the conversation (if they did not understand the material or lacked basic knowledge).

Students could independently test their knowledge of the topic and identify weak areas; if they gave an incorrect answer, the chatbot immediately suggested returning to the section of the material containing the answer, which allowed them to fill in the “gap” in their knowledge.

In this study, for the first time, virtual patients in the RUMEDIUS system actively communicated with students and answered questions regarding symptoms and medical history thanks to the integration of AI into the RUMEDIUS system software. This allowed students to practice communication skills that were as close to reality as possible in a simulated environment, without being in a medical facility (Fig. 5).

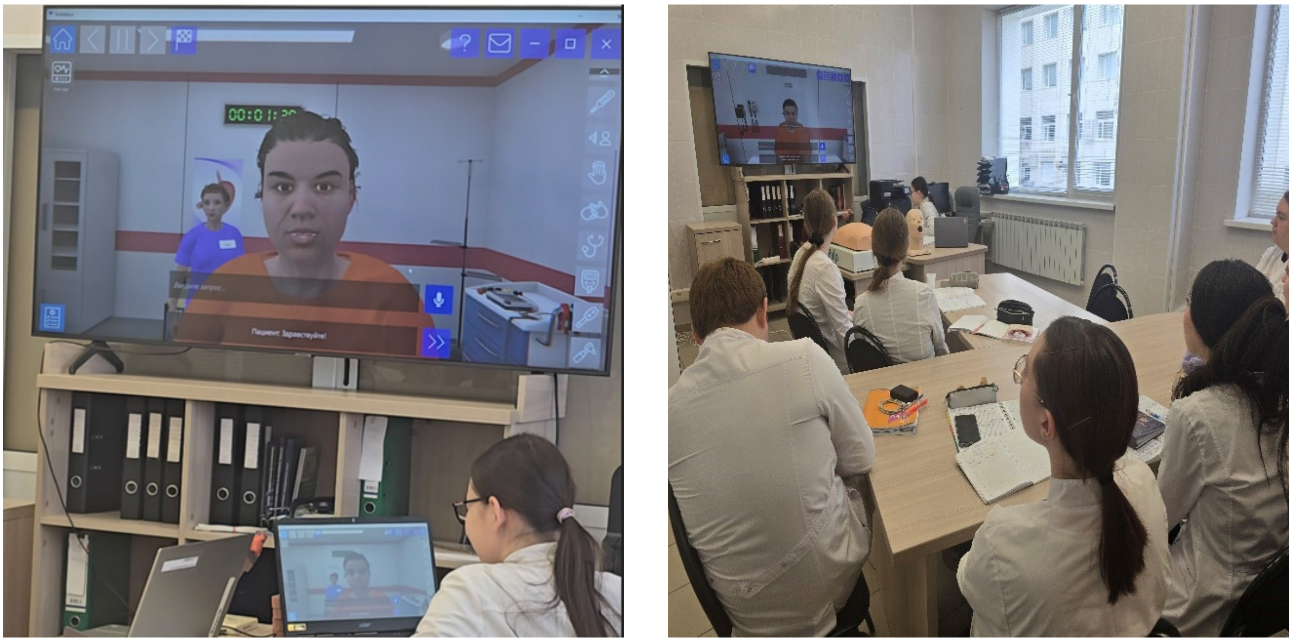

Fig. 5. Practicing communication skills with virtual patients in the RUMEDIUS system

It should be noted that when communicating with a virtual patient, situations arose that were as close as possible to real-life communication — situations where the patient did not understand the questions addressed to them. During classroom work, the instructor and students determined that the reasons for difficult interactions with virtual patients included: the doctor's soft voice, unclear diction, sentence structures that were unclear to the AI (e.g., overly long questions), and the use of medical terminology. Both during independent work and in classroom sessions, students playing the role of the doctor experienced frustration in response to difficult interactions with the virtual patient. This AI behavior demonstrated to the students the specific challenges of taking a medical history from patients with hearing loss, cognitive impairments, or language barriers, confirming the potential of AI for practicing communication skills. Following the study, the instructor observed, in real-world practice, that the EG students communicated much more freely with real patients compared to students trained using traditional methods.

Based on the results of the AI debriefing, the instructor structured their own debriefing to introduce each in-person practical session on the topic being studied. The results of their assessment of preparation based on theoretical materials and clinical cases were discussed with the students . The students noted that the AI assessed them objectively and at the level of a qualified university instructor: "You're telling us the same thing." The instructor saved a significant amount of time on checking homework assignments that require a qualitative assessment.

When developing the methodology, the leading hypothesis was that students in the experimental group (EG) would demonstrate better training outcomes than those in the control group (CG) due to an effective combination of simulators, virtual patients, and artificial intelligence. The initial assessment to evaluate basic knowledge showed that the EG and CG did not differ in terms of their level of preparation (Table 1).

The test included 20 questions on the section "Clinical Examination and Semiotics of Digestive System Lesions." The average score for basic knowledge in the EG group was 83.07%, and in the CG group, 81.2%. The pass rate in both groups was 93%. The quality of knowledge in the GI group was 75.86%, and in the CG group, 68.96%. The level of mastery among students in the EG was 64.55%, and in the CG—58.89%. No statistically significant differences in the indicators of success rates, quality of knowledge, and level of mastery were found when testing basic knowledge using the ϕ*-criterion.

Table 1

Qualitative assessment of the entrance test

Level of preparation	Learning outcomes EG (n = 29)		Learning outcomes CG (n = 29)		φ*-criterion
	abs.	%	abs.	%	
< 70%	2	6.9	2	6.9	0
≥ 70%	27	93.1	27	93.1	0
70–79%	5	17.2	7	24.1	0.527
80–89%	15	51.8	16	55.2	0.146
≥ 90%	7	24.1	4	13.8	0.838

Upon completion of the pilot testing of the Methodology, students took a final exam. The exam included 21 questions on the section covering diseases of the digestive system. The test results are presented in Table 2.

Table 2

Qualitative Assessment of the Final Test

Level of preparation	Learning Outcomes EG (n = 29)		Learning outcomes CG (n = 29)		φ*-criterion
	abs.	%	abs.	%	
< 70%	4	13.8	7	24.1	0.838
≥ 70%	25	86.2	22	75.86	0.328
70–79%	16	55.2	15	51.8	0.146
80–89%	8	27.6	7	24.1	0.231
≥ 90%	1	3.4	0	0	–

The average score on the final exam was 75.7% in the EG group and 74.6% in the CG group. The pass rate was 86.2% in the EG group and 75.86% in the CG group. The quality of knowledge in the EG was 31%, and in the control group (CG) — 24.1%. The level of mastery among EG students was 43.17%, and in the CG — 37.9%. No statistically significant differences were found in the indicators of success rates, quality of knowledge, and level of mastery when testing basic knowledge using the ϕ*-criterion.

Feedback on the use of AI in the educational process was provided by 21 students from the EG (72.4%). Students noted that learning had become more interesting — 85.7% (n = 18) of students, 90.5% (n = 19) saved time when preparing for classes, and 80.9% (n = 17) noted an improvement in academic performance. Artificial intelligence allowed students to organize material into tables, highlight key points, simplify information for better understanding, clarify unclear concepts, and create quizzes on the studied topic for self-assessment. All 100% of respondents reported that learning with AI was better and that they had applied AI in their studies of other subjects. There were no negative comments regarding their interaction with AI.

The final question in the survey was to rate their experience with AI on a scale of 1 to 10, where 1 is poor and 10 is excellent. Students rated the technology an average of 8.5 points.

The instructor also noted a reduction in workload, both when checking the results of independent work and during practical work in the classroom.

Conclusion

In the context of the rapid digitalization of practical healthcare, proficiency in digital technologies and artificial intelligence tools is becoming an essential professional competency for specialists [6; 7]. At the same time, the uncontrolled independent use of AI by students—obtaining ready-made answers to questions or solutions to problems of any level of complexity — calls into question the possibility of developing analytical and systematic thinking, including the clinical reasoning of a clinical medicine specialist during their professional development.

Students must be taught to use AI correctly as a technology and not turn it into yet another way to find quick answers. The technology of AI application includes teaching students the basics of prompting for productive interaction with AI regardless of the discipline. Artificial intelligence is, first and foremost, a learning technology, not a replacement for the instructor in the educational process. This technology is beneficial for struggling students and unmotivated students, as it adapts information to the student, can explain concepts at different levels (high school and academic), allows for the structuring of information, enables self-assessment of material mastery with instant feedback, and identifies areas that have not been sufficiently mastered. The use of publicly available chatbots does not require additional financial costs from the university or the student: there are Russian and foreign AI-based chatbots available for free use; all that is needed is a smartphone and internet access. The use of AI allows for personalized learning based on the student's psychological and cognitive characteristics.

The study found that the use of AI proved most effective in developing and refining communication skills in a simulated environment. The lack of statistical significance in the differences between learning outcomes using AI and those using traditional methods is ambiguous. On the one hand, the results could have been influenced by group size and the short observation period. On the other hand, no negative results were observed from the use of AI in the educational process, and according to the results of the final testing in the EG, the number of students who received unsatisfactory grades was lower.

Conclusions

1. A methodology has been developed for problem-based, competency-based, self-directed learning of basic clinical examination skills using simulators, virtual patients, and artificial intelligence.
2. No negative results were observed during the testing of artificial intelligence in the educational process at a medical university.
3. The combination of simulators, virtual patients, and artificial intelligence proved most effective in developing and refining communication skills in the "doctor-patient" system within a simulated environment.

Contribution of the authors

Graudina V. E., Kushnikova I. P., Shchelnikova A. S.: development of the methodology, processing and analysis of research results.
Shchelnikova A. S.: testing of the methodology.
All authors participated in the discussion and editing of the manuscript.
All authors approved the final version of the article.

Acknowledgments

The authors of the article express their deep gratitude to the RUMEDIUS educational platform for the opportunity to incorporate the case studies into the educational process, for ongoing technical support, and for the opportunity to test the expanded communication capabilities of virtual patients, as well as to the students who participated in the study.

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IMMERSIVE TECHNOLOGIES FOR IMPROVING THE WELL-BEING AND QUALITY OF LIFE OF PEOPLE WITH DISABILITIES: CURRENT SOLUTIONS AND IMPLEMENTATION CHALLENGES

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DOI: 10.46594/2687-0037_2026_1_2148

Abstract. This article examines the current and potential applications of virtual reality technologies for people with various physical limitations resulting from injuries or illnesses. The Russian market for virtual tools in medicine is examined, and the challenges faced by medical centers in Russia when using immersive technologies for rehabilitation and therapeutic interventions are identified. The shortcomings of current technologies in improving the satisfaction and quality of life of end-users with disabilities are highlighted.

Keywords: virtual and augmented reality technologies, inclusive environment, rehabilitation, people with disabilities, satisfaction and quality of life.

Conflict of interest. The authors declare no conflict of interest.

Citation: Vakhrushev R. A., Khalimanenko S. N., Cherezova Y. A., Yaksina U. A. Immersive technologies for improving the satisfaction and quality of life of people with disabilities: current solutions and application challenges // Virtual Technologies in Medicine. 2025. No. 4. Pp. 22–27. DOI: 10.46594/2687-0037_2026_1_2148

Scientific specialty: 3.2.3. Public Health and Health Care Organization, Sociology and History of Medicine

Received by the editorial office on November 17, 2025
Received after peer review on December 17, 2025
Accepted for publication on December 17, 2025

Introduction

Currently, virtual reality (VR) and augmented reality (AR) technologies are being applied in virtually all areas of life. Immersion (from the English word “immersive” — “presence, immersion”) is a mode of perception that creates the effect of being immersed in an artificially created environment [3]. In recent years, developers and users have aimed to create fully immersive virtual reality technologies, where the distinction between the illusory and real worlds is blurred. However, creating such a system involves a number of challenges, including the accessibility of these technologies to a wide range of users [2]. People with disabilities constitute a distinct group among them. The application of immersive technologies for this group should not be limited solely to rehabilitation following surgeries, injuries, and serious illnesses.

The aim of this study is to analyze current solutions and challenges regarding the use of immersive technologies by people with disabilities to improve their satisfaction and quality of life.

Materials and Methods

To achieve this objective, we analyzed publications on the research topic contained in Russian and international scientometric databases, including Scopus, Web of Science, and RINC, as well as online resources of VR equipment manufacturers, for the period from 2019 to 2025. In addition, we examined statistical data on the number of people with disabilities in the Russian Federation (hereinafter — RF) and their ability to lead an active lifestyle, the prevalence of virtual reality technologies in the RF and their application in medical centers within the RF, the availability of educational programs for training developers of VR and AR solutions, including in medicine, as well as virtual scenario simulations for training doctors and nurses.

Results

A review of the literature revealed a wide range of applications for virtual reality technologies in medicine: VR can be used to train students, improve staff skills, prepare patients for complex surgeries, and facilitate rehabilitation [4; 19]. VR can be and is successfully used to help people with physical or cognitive impairments regain lost functions or learn new skills. For example, VR helps stroke survivors regain limb mobility and helps people with cognitive impairments, such as autism, improve their social skills. VR can also be used in telerehabilitation so that people with disabilities can receive therapy remotely.

This, in turn, can be particularly useful in rural areas. In other words, the use of VR in medicine significantly expands the possibilities for both doctors and patients [13].

Unfortunately, even with the most modern and comprehensive approach to rehabilitation, VR is not a panacea and by no means always leads to the desired results. The success of rehabilitation efforts is strictly limited by a number of factors: the nature and severity of the underlying condition (for example, in cases of extensive damage to the central nervous system or progressive neurodegenerative diseases), the patient's age, the presence of comorbidities, and the timing of treatment initiation. In some cases, the destructive changes in the body prove to be irreversible, and rehabilitation aims only at adapting to a new quality of life, teaching self-care skills, and managing secondary complications, without addressing the primary impairment. Thus, despite all efforts, full or even partial functional recovery may prove unattainable, and the primary goal becomes maximizing the improvement of the patient's overall condition and social integration within the limits of available VR technologies.

However, practice shows that immersion in virtual reality — i.e., the complete blocking out of the real world through the display of a virtual reality environment — is currently not universally applicable or accessible to many people with disabilities [18]. The application of VR technologies could meet a much broader range of needs for people with disabilities. For instance, VR can help break down barriers to access information, education, and entertainment. This is particularly important for this group of individuals, who do not have the same ability as others to receive information from traditional media sources. For example, people with musculoskeletal disorders can use VR to visit a museum, and people with paralysis can participate in virtual sports competitions or other events. A person in a wheelchair can use VR to experience hiking through the mountains, or a person with visual impairments can use VR to explore a city or other space. This can provide an "escape" from the limitations of their physical abilities and allow them to experience what would otherwise be impossible.

However, challenges remain that hinder the most effective use of virtual reality technologies by people with disabilities. Thanks to growing interest from investors and developers in these challenges, some of them have already been addressed.

According to a study conducted by K. Gerling, P. Dickinson, et al., wheelchair users are highly attracted to VR games, although creating an immersive experience for people with disabilities requires careful planning [12]. For example, Beat Saber (destroying flying cubes with lightsabers to music), Job Simulator (performing humorous office tasks in the future), AudioShield (deflecting colored energy waves that correspond to the rhythm of the music), BoxVR (performing boxing exercises to music for training), and many other games across various genres are engaging and highly immersive. Now, players with disabilities can play the best VR games using the WalkinVR Driver assistive software [1].

Some examples of inclusive content include games that can be played without sound, offering real-time subtitles and audio-to-text conversion for users with hearing impairments or deafness. Games and apps designed for users with mobility impairments can also offer one-handed navigation or customizable controls [13].

Currently, VR games for the blind have been developed and are in use, in which blind people—wearing a pair of VR goggles, headphones, and a controller in each hand—can explore their surroundings using echolocation and feel as though they are in another world [16]. Such technologies can also be used by sighted people to foster empathy and understanding among the working-age population, allowing them to experience what it is like to have a disability (Fig. 1).

Fig. 1. Screenshot from the VR game Blind*

In addition, voice recognition technology is increasingly being integrated into VR and AR interfaces, allowing users to navigate virtual environments and interact with content without using their hands. This technology is particularly useful for users with mobility issues or fine motor impairments [13].

Another challenge for people with disabilities is the lack of haptic feedback in VR systems. Blind or visually impaired individuals may have difficulty navigating virtual environments without the ability to feel surfaces and objects within them. To address this issue, haptic feedback devices have been significantly improved. These devices simulate the sense of touch, such as gloves that vibrate, creating the sensation of touching an object or interacting with the virtual world [13]. Modern exoskeletons are capable of adapting to movements, making walking, flying, and swimming in the virtual world particularly realistic [11]. Such tactile experiences add a new level of immersion and accessibility for users with visual impairments. For example, thanks to new virtual reality sensors, it is possible to distinguish 20 types of fabrics by touch. Modern VR headsets are capable of simulating kisses and splashes of mud on the face [20].

* Source: URL: https://stratege.ru/forums/threads (accessed September 15, 2025).

Today, new technologies complement visual, auditory, and tactile sensations with aromatic effects [20]. Aromatic effects (olfactory technologies) in virtual reality can become not merely a supplement for blind users, but a key channel of information and a powerful tool for creating reality, compensating for the absence of the visual modality. The integration of scent-based stimulation into the digital environment not only enriches the immersive experience but also paves the way for more inclusive solutions for people with sensory or cognitive impairments [17].

1. Deep and intuitive immersion in the environment:
   - sense of place. A sighted person understands that they are in a forest by looking at an image. Blind people lack this information and, consequently, must rely on compensatory sensory channels and alternative methods. Research shows that smell is a rich source of contextual information for spatial orientation [14]. A blind person can gain the same understanding instantly through scents: the smell of pine needles and damp earth, the scent of decaying leaves in autumn, the aroma of blooming linden trees. This creates context and atmosphere faster and more effectively than any audio description;
   - navigation and spatial orientation. Scents can serve as navigational markers [17]. For example, the smell of fresh baked goods can lead to a virtual bakery, the scent of sea salt and seaweed can indicate approaching the shore, and the smell of smoke can warn of a dangerous area.
2. Enhancing and enriching the narrative and plot:
   - on an educational tour of Ancient Egypt, the scent of incense and papyrus will create a much stronger sense of presence than sound alone;
   - In a quest or story, the appearance of the smell of ozone can signal the activation of a "time machine," while the smell of old wood and dust can transport the hero to the attic of an old house, where a key part of the plot begins.
3. Improving the accessibility of games and simulations:
   - taaactical cues. In a game, scent can be an important gameplay element. For example, in an adventure game, a visually impaired player might search for a hidden object based on its unique scent (e.g., an oak chest smells of old wood and metal);
   - danger warnings. The smell of burning or smoke can serve as an indicator of an approaching threat (a fire, an enemy with a flamethrower), giving the player time to react.
4. Emotional impact and strengthening the connection with content:
   - Scents are directly linked to the brain's limbic system, which is responsible for emotions and memory. A study published in ACM Computing Surveys explores the design of olfactory displays for virtual reality environments, noting how the integration of scents enhances immersion and emotional engagement. Early prototypes are wearable devices that synchronize microdoses of synthesized scents with visual cues, overcoming longstanding limitations of multisensory experiences [10]. The scent of freshly cut grass can evoke feelings of calm and nostalgia, while the smell of gunpowder and dust can trigger anxiety and tension. This allows for the creation of much stronger and more memorable emotional experiences than when using sound alone.
5. Compensating for information and creating a more complete picture of the world:
   - in the real world, blind people actively use their sense of smell to gather information about people, objects, and places [6]. Scented VR brings this effective strategy into the virtual space. Smell allows us to "see" what cannot always be described in words or sound: the freshness of a meal just cooked, the distinct smell of a hospital, the unique atmosphere of a temple.

One of the biggest challenges for people with disabilities is that many VR systems require the use of a handheld controller for navigation and interaction with the virtual environment. This can be a problem for people with mobility impairments, such as cerebral palsy or multiple sclerosis, who have difficulty moving their hands. To solve this problem, researchers are developing new forms of input, such as eye tracking and brain-computer interfaces, which allow users to control VR systems using their eyes or thoughts. Neuralink is currently testing a device designed to help people with spinal cord injuries. This chip is a neural interface that is implanted in the brain. The device can function even if a person has no eyes at all, by connecting to the brain's visual centers. This allows the device to transmit visual signals directly to the brain, bypassing the eyeball and the optic nerve. As a result, patients can receive visual images even if their visual system is not functioning [9]. However, as of today, the technology is potentially capable of helping only if blindness is caused by damage to the eyes or optic nerves, while the patient's visual cortex remains fully intact.

The use of VR to treat mental disorders and depression in individuals who have suffered from serious illnesses — which, in turn, have led to disability or physical limitations — is becoming increasingly important [15]. For example, among stroke patients, post-stroke depression is the most common mental disorder, developing in approximately one in three patients. According to some data, the prevalence of post-stroke depression reaches 60%. On average, depression develops immediately after a stroke in 50% of patients, during the acute phase in 12%, and during the early and late recovery phases in 29% and 9%, respectively [7]. The technology has also shown good results in the treatment of post-traumatic stress. It allows a person to be transported back to the moment when they experienced psychological trauma. This helps them understand the nature of their fear, its cause, and find ways to cope with it. The same applies to childhood trauma [19].

Furthermore, according to sociological studies conducted by Russian researchers, the level of life satisfaction among people with disabilities remains low and shows signs of instability. At the same time, their dissatisfaction with the material aspects of life is compounded by an even higher level of dissatisfaction with the existing opportunities for realizing their life strategies. Over a long period, the emotional state of people with disabilities is characterized by heightened anxiety, pessimism, and uncertainty about the future. Despite having relatives, friends, and acquaintances, many of them feel lonely or neglected. Factors that significantly improve the social well-being of people with disabilities in middle age include the opportunity to engage in work activities [5]. The innovative capabilities of VR technologies, combined with a brain-computer interface, could address this challenge in the future.

Possible applications of immersive technologies depending on the type of health impairment are summarized in Table 1 for clarity.

Table 1

Areas of application for immersive technologies depending on the type of health impairment

<table>
<tr><th rowspan="2">Types of health impairments</th><th colspan="3">Areas of application for immersive technologies</th></tr>
<tr><th>Education</th><th>Information</th><th>Entertainment</th></tr>
<tr><td>For people with musculoskeletal and mobility impairments</td><td colspan="2">Visiting virtual museums, historical sites (such as Ancient Rome or the Egyptian pyramids), scientific laboratories, or participating in geographical expeditions that are physically inaccessible. This breaks down the barriers imposed by a wheelchair or limited mobility</td><td>Active participation in games and simulators requiring physical movement (sports, dancing, adventures) that are impossible in real life. VR allows users to “run,” “fly,” and “swim,” providing physical and emotional sensations that would otherwise be inaccessible. Wheelchair users can experience hiking through the mountains, participate in virtual sports competitions, or play exciting games such as Beat Saber and Job Simulator using adaptive technologies, such as the WalkinVR Driver. For users with fine motor skill challenges, the integration of voice recognition technology allows them to control interfaces without using their hands</td></tr>
<tr><td rowspan="2">For people with visual impairments</td><td>Haptic feedback devices (such as vibrating gloves) simulate the sensation of touching objects, allowing users to explore complex shapes and models “by touch,” converting visual information into tactile feedback. For example, haptic controllers with feedback can be used to explore complex shapes and models (such as molecular structures or sculptures)</td><td>Echolocation technologies in VR help explore virtual space. Audio description and 3D sound in virtual spaces allow users to “hear” a city’s architecture, navigate a virtual museum using voice prompts, or receive information about objects through their audio descriptions</td><td>Special audio games and simulations where spatial sound perception plays a key role (such as detective quests or musical adventures) provide a full-fledged gaming experience. VR games specifically designed for the blind use headphones and controllers so that the user can feel as though they are in another world, navigating by sound</td></tr>
<tr><td colspan="3">Aromatic effects (olfactory technologies) in virtual reality can become a key channel of information for blind users and a powerful tool for creating reality, compensating for the absence of visual cues. For example, scents can convey additional information about works of art to blind people (the so-called Proust phenomenon).
Modern developments, such as the Neuralink neural interface, may in the future be able to transmit visual images directly to the brain, bypassing the non-functioning visual system</td></tr>
<tr><td>For people with hearing impairments</td><td colspan="2">Any virtual content (lectures, tours, instructions) can be provided with subtitles integrated directly into the field of view or accompanied by visual cues. This creates a “seamless” and comfortable environment for perception</td><td>Games and entertainment apps can emphasize visual effects, haptic feedback from controllers (simulating vibrations from explosions or footsteps), and the conversion of audio signals into visual cues, ensuring full immersion. Some games are designed with the ability to convert audio to text</td></tr>
<tr><td>For individuals with cognitive impairments (ASD[1], ADHD[2]), mental disorders, and psychological trauma</td><td>Creating controlled, predictable, and calm learning environments where social skills and scenarios (such as going to the store or a job interview) can be practiced without the sensory overload of the real world</td><td>VR technologies are used for therapy (e.g., exposure therapy for phobias or PTSD[3]), allowing users to safely and gradually confront their fears and learn to manage their reactions to them</td><td>Relaxing virtual worlds help relieve stress and anxiety, serving as a form of digital relaxation, which is particularly important for a group characterized by heightened anxiety and feelings of loneliness</td></tr>
<tr><td>Versatile and futuristic solutions for people with various health conditions</td><td colspan="3">Haptic feedback, such as the further development of exoskeletons and gloves, will make walking, flying, and interacting with the virtual world feel realistic, adding a new level of immersion for all users.
Developments in brain-computer interfaces (BCIs) and eye-tracking open up fundamentally new possibilities for controlling VR systems for people with severe forms of paralysis (e.g., cerebral palsy or multiple sclerosis)</td></tr>
</table>

[1] ASD — autism spectrum disorder.
[2] ADHD — attention-deficit/hyperactivity disorder.
[3] PTSD — post-traumatic stress disorder.

The development of immersive technologies, including haptic feedback devices, has the potential to improve the quality of life for a large number of people. According to Rosstat data [8], as of December 31, 2023, there were 75.5 people with disabilities per 1,000 population in the Russian Federation, including children with disabilities. The distribution of people with disabilities by age in the Russian Federation as of January 1, 2023, is shown in Figure 2.

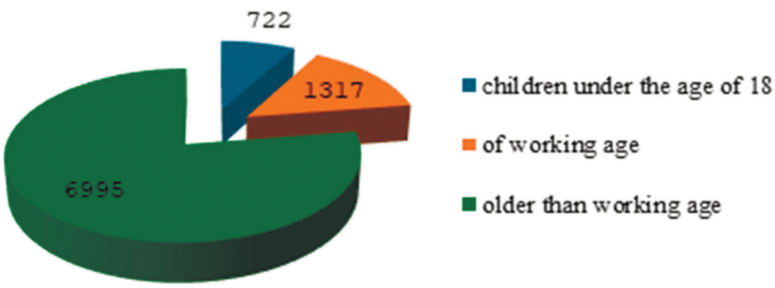

Fig. 2. Distribution of people with disabilities by age in the Russian Federation as of January 1, 2023, thousands of people*

According to data from the Federal State Statistics Service [8], as a result of a comprehensive survey of living conditions in 2022, only 7.9% of respondents among people with disabilities aged 15 and older assessed their ability to lead an active lifestyle. The remaining respondents are unable to lead an active lifestyle because their health and/or age prevents them from doing so (86.7%) or because they have no interest or desire to lead an active lifestyle (5.4%). For greater clarity, the results are presented in Figure 3.

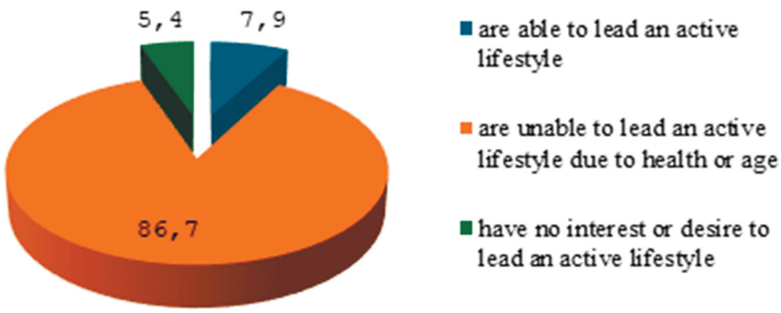

Fig. 3. The ability to lead an active lifestyle for people with disabilities aged 15 years or more, %**

These results confirm the need to increase interest in an active lifestyle and overall quality of life among people with disabilities, including through the use of virtual reality technologies. According to researchers [18], the decreasing cost of virtual reality headsets (HMDs) and real-time VR tracking equipment may soon lead to their widespread adoption in homes around the world.

A study on the use of immersive technologies in Russia for people with disabilities yielded data that identified strengths and weaknesses, as well as opportunities for their application and threats that medical centers and end users with disabilities may face. Based on the data obtained, a SWOT matrix was constructed, as presented in Table 2.

Conclusion

Thus, we have determined that the main barriers to the adoption of immersive technologies in the Russian Federation remain the failure of equipment to meet technical and user requirements, high cost, a lack of content and specific equipment functionality, and a shortage of qualified developers and medical personnel with the necessary competencies. At the same time, the growing interest of developers and investors in addressing these challenges opens up new horizons for people with disabilities in terms of active living, rehabilitation, education, and entertainment. Virtual reality technologies have the potential to transform how people interact with the world and can make it more inclusive and accessible, while improving the satisfaction and quality of life for people with health impairments.

Authors' contributions:
Ruslan Antonovich Vakhrushev — literature search and analysis (technical information);
Sergey Nikolaevich Khalimanenko — literature search and analysis (medical information);
Yana Alekseevna Cherezova — article formatting, statistical data processing;
Ulyana Alekseyevna Yaksina — Literature Search and Analysis (Mental Disorders).

* See the Rosstat website: URL: rosstat.gov.ru (accessed: 09/15/2025).

** See the Rosstat website: URL: rosstat.gov.ru (accessed: 09/15/2025) (based on data from the Comprehensive Survey of Living Conditions).

Table 2

SWOT Analysis of the Application and Development of Virtual and Augmented Reality Technologies for People with Disabilities in Russia

Strengths:	*Weaknesses:*
· realistic imagery; · intuitive controls; · positive results from the use of VR tools for rehabilitation and treatment; · real-time interaction; · availability of some forms of haptic feedback	· equipment that does not meet technical and user requirements; · high cost of tools; · lack of content and specific equipment functionality; · lack of qualified developers and medical personnel with the necessary skills; · low patent activity; · insufficient publication activity by domestic researchers; · potential negative health effects
Opportunities:	*Threats:*
· high innovation potential; · growing investor interest in further development; · growing interest from users and healthcare organizations; · desire for full immersion in virtual reality	· lack of information on current usage results; · unpredictability of external factors; · lack of research on long-term health effects

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USE OF AN INTERACTIVE ANATOMICAL COMPLEX IN A REGIONAL SUBJECT COMPETITION AMONG STUDENTS IN THE FINAL YEAR OF VOCATIONAL SECONDARY EDUCATION

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DOI: 10.46594/2687-0037_2026_1_2157

Abstract. This article describes the potential applications of the "Pirogov" interactive system in conducting a regional subject competition in human anatomy and physiology for students majoring in 34.02.01 "Nursing" (N) and 31.02.01 "General Medicine" (GM). It reveals the effectiveness of using interactive simulators in teaching and developing professional skills among students. In accordance with the current federal state educational standard for the course module, students must: know human anatomy and physiology and be able to apply knowledge of anatomy and physiology to examine patients and make a preliminary diagnosis. The results obtained will allow for adjustments to educational activities.

Keywords: "Pirogov" interactive anatomical complex, creative competition, team assignment, innovative methods.

Conflict of interest. The authors declare no conflict of interest.

Citation: Menshikova E. A., Mardarovskaya T. A., Lyubov A. S. Use of an interactive anatomical system in a regional subject competition among final-year students of secondary vocational education // Virtual Technologies in Medicine. 2026. No. 1. Pp. 28–33. DOI: 10.46594/2687-0037_2026_1_2157

Scientific specialty: 3.3.1 "Human Anatomy," 3.2.3. Public Health and Health Care Organization, Sociology and History of Medicine, 3.1.4. Obstetrics and Gynecology.

Received by the editorial office on February 5, 2026.
Received after peer review on March 4, 2026.
Accepted for publication on March 4, 2026

Introduction

The implementation of interactive teaching methods is one of the most important areas for improving student training in the medical professional education system. These tools allow students to visualize anatomical structures in three-dimensional space. The "Pirogov" Anatomy Complex is not merely a 3D anatomy atlas, but a collection of numerous detailed structures depicting the normal and pathological human anatomy, accompanied by comprehensive descriptions [1].

Working with interactive equipment allows users to view objects from any angle, zoom in or out, examine them in different planes, hide or restore human organs to the anatomical scene, obtain detailed textual descriptions of the displayed 3D objects, and study the Latin terms for anatomical structures. Any pedagogical technology is an information technology, since the technological process of learning is based on the acquisition and transformation of information [3]. The most important area is the use of digital educational technologies with interactive equipment. Modern virtual reality tools are viewed as a source of technological opportunities in education and medicine, complementing the set of traditional approaches to teaching.

Research Objective

To analyze the experience of using the "Pirogov" anatomical complex, reveal the advantages and disadvantages of this virtual reality technology, and determine the organizational and pedagogical conditions for its effective use in preparing students of secondary vocational education for the regional academic competition.

Materials and Methods

In November 2025, a regional subject Olympiad was held at the Arkhangelsk Medical College for students of state vocational educational institutions in the Arkhangelsk Region in the specialties 31.02.01 "General Medicine" and 34.02.01 "Nursing". The venue for the regional competition among vocational educational institutions in the Arkhangelsk Region was the classroom of the Primary Simulation and Accreditation Educational Center at the Arkhangelsk Medical College. The program for the regional competition was developed jointly by T. A. Mardarovskaya, instructor of obstetrics and gynecology, and A. S. Lyubov, acting director of the Arkhangelsk Medical College (AMC) and instructor of the fundamentals of resuscitation.

Objectives of the regional competition among students of secondary vocational education in the Arkhangelsk Region:

- to stimulate intellectual curiosity;
- to consolidate and systematize knowledge;
- to develop intellectual and professional competencies;
- to develop creative and communication skills.

The “Pirogov” anatomical complex is designed for examining and documenting specimens during dissections, helping medical students understand the relationships between organs. The «Pirogov» interactive tables are modern 3D atlases with touchscreens that allow users to study normal and pathological anatomy, ultrasound, CT, and MRI in an interactive mode. The software generates tests linked to 3D models to assess mastery of the material and automatically process results, improving knowledge retention by 20% compared to traditional methods.

The structure of the competition task on “Human Anatomy and Physiology” included a test, an intellectual quiz called “Your Game,” and a creative contest.

The subject test consisted of 50 test items of varying difficulty: single-choice, multiple-choice, matching, and sequencing tasks . Students were given 60 minutes to complete the test. The “Your Game” quiz included questions on the body’s systems (cardiovascular system, digestive system, nervous system, musculoskeletal system, endocrine system) and lasted 30 minutes. Each section on the body’s systems contained 5 questions, each worth 1 point. In total, the quiz consisted of 25 questions.

The creative competition took place at the Pirogov Anatomical Complex over a 90-minute period and was a team event. The following educational scenarios were presented during the competition: locating and describing anatomical structures, describing the topography of organ structures, creating anatomical models and scenes, and solving clinical problems. Participants were given a choice of questions. Each task was worth 1 point, with an additional 1 point awarded for the situational task. The creative competition consisted of a total of 8 tasks, worth 11 points in total. The tasks were divided among 2 teams of participants, with 4 questions to choose from.

The tasks in the creative competition included the following questions:

Task 1. Demonstrate and describe on an anatomical model the origin of the arteries of the female reproductive system.

Task 2. Locate and demonstrate the sinoatrial node of the heart on an interactive stand.

Task 3. Create an anatomical model of the respiratory organs. Identify the tracheal bifurcation. Solve a case study: a child has aspirated a foreign body into the airways. Which bronchus is the foreign body likely to enter?

Task 4. Locate the pancreas on the interactive display. Demonstrate that the pancreas is a mixed-secretion gland. Solve the following scenario: A person ate a buttered sandwich. Explain how the ingested food will change as it moves through the digestive tract.

Task 5. Solve the following scenario: A person suddenly lost consciousness and stopped breathing while defecating. Cyanosis of the head, neck, and shoulder region is immediately apparent. What do you think happened to the patient? Identify the anatomical structure on the “Pirogov” model that caused the problem.

Task 6. Identify the visceral branches of the internal iliac artery using the “Pirogov” model.

Task 7. On the anatomical model, recreate the pulmonary circulation and find the “error” in the vessels.

Task 8. Using the “Pirogov” model, demonstrate the location of the pituitary gland. Describe the structure and function of the gland.

Sixteen people participated in the competition (Table 1), 12 of whom are students in their final year of study in the following programs: 31.02.01 — “Nursing” (N) and 34.02.01 — “General Medicine” (GM) at secondary medical educational institutions in the Arkhangelsk Region. For the purposes of analyzing the competition results, the students were divided into two groups (the N department group and the GM department group).

Table 1

Total number of Olympiad participants

No.	Role name	No. of participants
1	Students of the N Department	6
2	Students in the GM department	6
3	Jury	2
4	Instructors (experts)	2
Total		16

Descriptive statistics were used in the analysis of the results, showing the average score and the percentage of the analysis.

Upon completion of the competition, a feedback survey was conducted among participants, in which students were asked to answer the following questions:

1. Please indicate your status at Arkhangelsk Medical College and other secondary vocational education institutions in the Arkhangelsk Region.
2 How often did you study at the simulation center for the course “Human Anatomy and Physiology”?
3. What forms of instruction do you find useful and helpful for your learning?
4. What sources did you use to acquire theoretical knowledge of human anatomy and physiology?
5. What practical skills do you practice in anatomy classes using the “Pirogov” interactive system?
6. What knowledge of human anatomy and physiology do you possess?
7. Were there any assessments of your knowledge after the topics covered in the practical classes?
8. How well do you understand human anatomy and physiology?
9. Are you satisfied with the level of practical training in this discipline?
10. What difficulties do you encounter when using the interactive anatomical equipment?

The survey material on the use of the anatomical complex is provided in Appendix 1 and is included at the end of the article.

Results and Discussion

The curriculum for "Human Anatomy and Physiology" serves as the foundation for developing general and professional competencies in future specialists with secondary medical education. Innovative devices in modern education help display, record, and analyze information [2]. The "Pirogov" anatomical system is a complex comprising numerous detailed structures of the normal and pathological anatomy of the body, with built-in descriptions in Russian and Latin.

The final results of the regional competition were as follows.

The average score for the regional competition among students in the "General Medicine" vocational program was 54 points, while among students in the N department it was 35.5 points.

The performance level on the first stage of the test among students in the "General Medicine" program was 1.6 times higher than that of students in the N department (39 and 27 points, respectively). The assessment results of the test tasks among participants from the General Medicine department and Nurse Department programs were evaluated as a percentage: 4 points—78% and 3 points—55% correct answers, respectively (Fig. 1).

Fig. 1. First stage of the testing competition

Thus, at the conclusion of the first stage of the regional vocational education Olympiad among students in the Arkhangelsk region, students in the GM department achieved 78% correct answers, while students in the N department achieved 54% (Fig. 2).

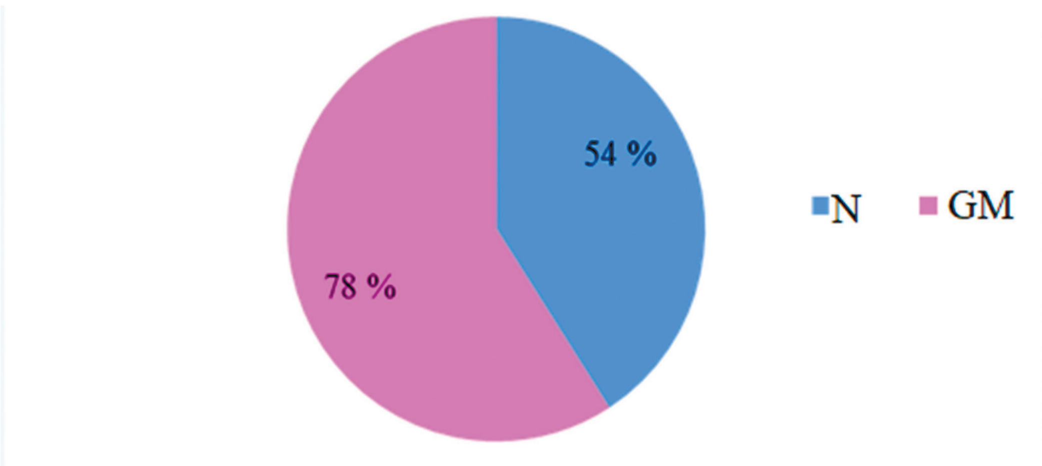

Fig. 2. Test results (%)

At the conclusion of the second stage of the regional academic competition—the intellectual quiz "Our Game"—students from the GM department also scored higher: 8 points and 4 points, respectively, compared to participants from the N department. The average score for students in the GM department was 75%, while for those in the N department it was 50% (Fig. 3).

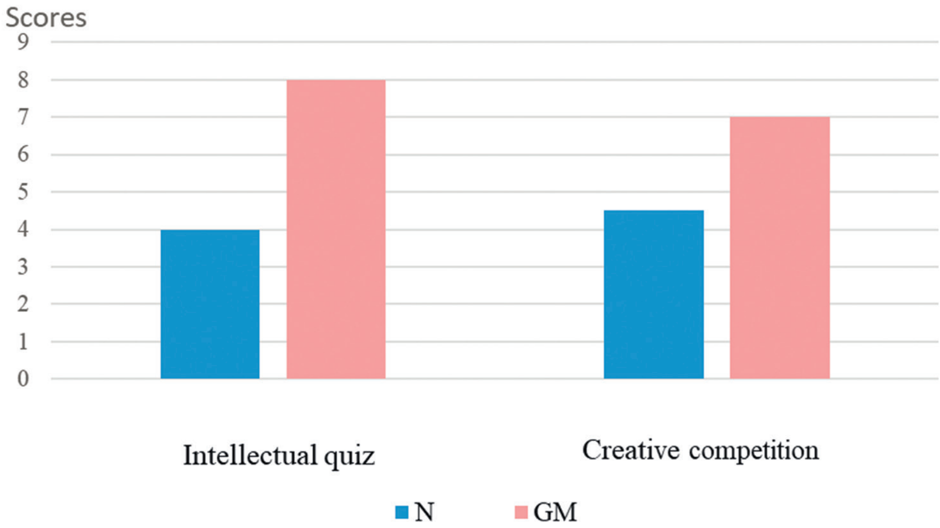

Fig. 3. Students' scores in the 2nd and 3rd stages of the regional competition (points)

Students from the N department provided incomplete answers to the regional Olympiad questions; there were quite a few errors on topics related to the cardiovascular system, as well as on tasks involving the correspondence and sequence of anatomical structures and physiological processes. It should be noted that in the creative competition, participants from the GM group also achieved the highest score, earning 7 points (87.5%) compared to the N group's 4.5 points (56.3%). A total of 11 points were available for the creative competition. The two teams of Olympiad participants were assigned optional tasks. Each task was worth 1 point, with an additional 1 point awarded for the situational task.

The creative competition is the final stage of the regional Olympiad in the completion of tasks on human anatomy and physiology. At this stage, students' cognitive activity and its application in learning are analyzed (Fig. 4).

The final tally of points shows that the maximum score for the test was 50 points, for the intellectual quiz — 25 points, and for the creative task — 8 points. The total maximum score for the regional competition among vocational school students in the Arkhangelsk Region is 83 points, encompassing all three stages of the competition.

Fig. 4. Students completing the creative competition tasks

Students in the graduating classes demonstrated the best knowledge in the areas of the structure and function of the endocrine system, the gastrointestinal tract, and the reproductive, urinary, and immune systems. In addition, the contest participants had difficulty with questions regarding the cardiovascular system, the nervous system, and the musculoskeletal system.

Students from the GM department achieved the best results, as the curriculum at Arkhangelsk Medical College included both traditional and interactive teaching methods, compared to students from the N department. This pattern is due to the fact that students at other educational institutions in the Arkhangelsk region do not have access to practical training using the "Pirogov" interactive anatomical complex. Interactive learning was conducted through theoretical foundations, which is ineffective in education.

Analysis of the questionnaire revealed that students showed the greatest interest in a model combining traditional and interactive teaching methods (N — 67% and GM — 100%). Students justified their answers by stating that the use of interactive information when preparing a topic facilitates the understanding of theoretical material, which is reinforced by the instructor's comments and demonstrations on a touchscreen display. It was noted that knowledge assessments are consistently conducted after practical sessions (100% — N, GM). The survey results revealed that 83% of students in the GM department possess theoretical and practical knowledge of anatomy. However, among students in the N department, this figure was 1.6 times lower — 50%.

A survey revealed that the satisfaction rate with practical training among GM students was 100%, while among N students it was 83%. These figures indicate that nursing students at other secondary vocational education institutions in the Arkhangelsk region do not have classes using the "Pirogov" interactive anatomical system. The difficulties in learning to use the interactive equipment stem from the need to master a large volume of theoretical knowledge and practical skills within a short training period. A small proportion of vocational education students experience difficulties with the interactive anatomical system, attributing this to the lack of network solutions and compatibility with mobile platforms.

Conclusion

The results obtained underscore the importance of holding a regional subject competition among vocational school students and the need for further improvement of educational programs aimed at developing practical skills based on theoretical knowledge. Interactive equipment allows for the active engagement of students in the learning process and the implementation of various educational technologies. The combined use of various digital technologies and interactive equipment enhances the effectiveness of the educational process and enables the assessment of knowledge acquired by students in graduating classes.

Conclusions

Thus, the implementation of virtual reality tools expands the boundaries of the principles of clarity and accessibility, resolving many traditional challenges. Working with the anatomical atlas already demonstrates improved student perception and understanding of anatomy, fostering clinical spatial thinking. Students showed great interest in the illustrated interactive educational material. Interactive learning increases participants' motivation to solve the problems under discussion, which provides an emotional impetus for subsequent research activity and encourages them to take concrete actions. The interactive approach stimulates students' cognitive activity, fosters professional interest, develops spatial thinking, and prepares specialists capable of both independently solving assigned tasks and engaging in collaborative interaction with fellow students.

At the same time, the use of interactive equipment allows for the individualization of the learning process, stimulates interest in completing tasks, and enhances motivation and cognitive activity. Through the use of interactive learning in education, the goals of aesthetic education are achieved, along with the development of communication skills, the formation of the ability to make optimal decisions or propose alternative solutions in complex situations, and the ability to process information. Interactive teaching methods create the necessary conditions for developing the ability to think independently, navigate new situations, and find one's own approaches to problem-solving.

Contributions of the authors

Menshikova E. A. collected the material and analyzed and interpreted the data for this publication.
Mardarovskaya T. A. participated in the discussion of the research results and finalized the article.
Lyubov A. S. developed the concept and design of the study.
All authors participated in drafting the manuscript and approved the final version of the article.

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Appendix 1

Student Survey on the Use of the Pirogov Anatomical Complex

1. Indicate your status at Arkhangelsk Medical College and at other educational institutions:
   Year ______________________________
   department ______________________________
2. How often have you taken courses in the simulation center on the subject of «Human Anatomy and Physiology»?
   constantly ______________________________
   Sometimes (rarely) ______________________________
3. Which teaching methods do you find useful and helpful for learning?
   Traditional format ______________________________
   Interactive format ______________________________
   Both options ______________________________
4. What sources did you use to acquire theoretical knowledge of human anatomy and physiology?
   Lectures by instructors ______________________________
   course materials ______________________________
   Information from the Internet ______________________________
5. What practical skills do you practice in anatomy classes using the Pirogov interactive system?
   create an anatomical scene ______________________________
   remove or isolate an organ ______________________________
   describing an anatomical object ______________________________
   Other ______________________________
6. What knowledge of human anatomy and physiology do you possess?
   topography of organs ______________________________
   structure of organs ______________________________
   Functions of organs ______________________________
7. Were there any assessments of knowledge after the topics covered in the practical sessions?
   Yes ______________________________
   No ______________________________
8. How well do you know human anatomy and physiology?
   sufficient ______________________________
   Insufficient ______________________________
9. Are you satisfied with the level of practical training in this discipline?
   Yes ______________________________
   Partially ______________________________
   No ______________________________
10. What difficulties do you experience when using interactive anatomical equipment?

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“THE ERMAKOV CODE.” AN ATTACK ON FORMALISM IN EDUCATION AND THE TEACHING CORPS

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DOI: 10.46594/2687-0037_2026_1_2159

Dedicated to our friend and colleague
M. D. Gorshkov on his birthday, February 6, 2026

Abstract. New legislative requirements, restrictions on remote formats, and the growing expectations of employers and patients require nursing staff to adapt their practices. However, there are challenges in organizing professional development, indirect consequences of outdated approaches, and the benefits of modern training models are not immediately apparent. This article proposes scientifically grounded pedagogical technologies to overcome these barriers. Particular attention is paid to shared responsibility, support, and the motivation of colleagues. The article is addressed to practicing nurses and nursing managers. It contains practical recommendations for implementing new training methods without interrupting work.
Keywords: continuing professional education, in-situ simulation, professional development, simulation-based training, continuing education, scientific approaches, practical experience, motivation, organizational barriers.
Conflict of interest. The authors declare no conflict of interest.
Author Lyubov Borisovna Shubina declares that she is a member of the editorial board of the journal “Virtual Technologies in Medicine.” The article did not undergo an independent peer-review process and is published in the “Opinion piece” section.
For citation: Shubina L. B., Gribkov D. M. “The Ermakov Code.” An Attack on Formalism in Education and the Teaching Assault // Virtual Technologies in Medicine. 2026. No. 1. Pp. 34–37. DOI: 10.46594/2687-0037_2026_1_2159
Scientific specialty: 3.2.3. Public Health and Health Care Organization, Sociology and History of Medicine
Received by the editorial office on February 10, 2026

“Training is not a parade. A parade is beautiful, but here it has to be real.”
From the film “The Attack” (1986)

Introduction

In the fall of 2025, at the annual Conference of the Russian Society for Simulation-Based Education (ROSOMED), we raised the question of the values of simulation-based education, and the Soviet film “Attack” (1986) was suggested for viewing as a metaphor.

Let us examine the parallels between this film and contemporary training in the continuing professional education (CPE) system for medical professionals. It is currently undergoing yet another round of reforms related to the ban on fully remote professional development programs and professional retraining courses.

A systemic conflict between theory and practice

Comparing the film **“Attack” (1986)** with the current situation in CPE is a profound and painful metaphor. Over the past 40 years, the setting has shifted from tank training grounds to simulation centers, but the systemic conflict remains the same. The film’s protagonist, young Lieutenant Ermakov, faces the same wall that we and our colleagues engaged in simulation training face today.

In the film, the command is accustomed to conducting “pretty” exercises by the book, where the enemy is predictable and victory is guaranteed by a report. Ermakov’s real tactics and initiative are perceived as an annoying hindrance to the “well-rehearsed scenario.”

In the continuing professional education system, it’s easier to “click through” tests (paper exercises) than to face the messy, complex reality in a simulation center. Proper simulation training is an Ermakov-style attack that exposes the holes in the defense that everyone has agreed to ignore. In the film, senior officers rest on the laurels of past achievements, but in the context of modern warfare, their methods are a path to the destruction of crews.

In continuing professional education, it’s our instructors who are afraid to approach a mannequin. They teach using 20-year-old manuals and shy away from an experienced nurse because they’ve lost touch with the “field.” Their authority rests on their rank (status), not on their skill. At the same time, an instructor is not required to be the best at inserting a catheter. Their task is to know modern protocols and be able to lead group training sessions where no one doubts the expertise of the practicing specialists. The goal of continuing professional education is to align practices with modern, evidence-based protocols and, if doing so in practice is impractical, to discuss how to adapt them.

In the film, Yermakov realizes that in a real battle, tank crews will pay with their lives for the mistakes of opportunists. The concept of a “silent catastrophe” is used. The catastrophe does not result from actual explosions, but from errors on staff maps and the loss of communication. A massive combat unit instantly turns into a "dead" mass of equipment at the command of intermediaries who simply stop transmitting orders and turn off their radios. The only unit that "survived" (did not enter the strike zone) turns out to be Lieutenant Timofey Yermakov's forward outpost. Left without communication with the "lost" headquarters, Yermakov decides to act independently, basing his decisions on the actual situation rather than on the headquarters' hypothetical scenarios. This scene serves as a pivotal moment in the film, criticizing formalism in the peacetime army and emphasizing the importance of a commander's and team's competence in chaotic conditions.

In continuing professional education, flaws in communication, the identification and prevention of emergencies, and the techniques of manipulation during "peacetime" are precisely those "invisible disasters." The chief physician, for whom the absence of complaints is more important than competence, is a reflection of that very general for whom the evaluation of exercises is more important than the regiment's actual combat readiness. "Invisible disasters" in medicine are invisible errors, inaccuracies, and formalism, the cumulative effect of which is comparable to a disaster.

When training centers sell certificates and doctors and nurses buy them without actually acquiring the necessary skills, a "silent" skills shortage arises. On paper, this is 100% trained staff, but in reality, these are people who struggle to operate new equipment or respond professionally to difficult patients. Errors accumulate over the years until a fatal incident occurs that cannot be attributed to chance. Staff stop seeing the risk — "We've always done it this way, and nothing has happened."

Sooner or later, the "holes" in the defense (the Swiss cheese model) will align, and a patient will receive the wrong medication or a healthcare-associated infection. An awkwardly placed call button, illegible handwriting on a prescription sheet, or a lack of antiseptic at a critical point. In calm times, this is "just an inconvenience." In a critical situation, it's an extra 30 seconds that cost a life, and an unnoticed disaster within the team. When healthcare workers feel that their education is a travesty and their work is an assembly line, they stop "engaging" their clinical thinking and taking pleasure in their chosen profession. The patient becomes an "object," and a complaint becomes a reason for retaliatory aggression rather than for analysis. "Invisible disasters" are prepared during peacetime exercises (in lecture halls) but occur in "combat" (at the patient's bedside). And during continuing professional education, one can use the research approach: "What is one 'invisible' problem in the department that we've all gotten used to ignoring, but which could 'explode' at any moment?" This would be the start of a real investigation. Is it possible to do this in a remote format?

In the film, Ermakov takes a risk by breaking the rules to demonstrate: "You can't fight the way they teach you now." In continuing professional education, meaningful hands-on training is a "rebellion" against formalism. Real learning allows us to "wake up and look around," feel the thrill of true mastery, and spot mistakes before they become fatal. It's not easy. There will be a lot of skepticism and discomfort. It is also important not only to identify mistakes but also to ensure that everything contributes to providing quality medical care and creates a reliable safety net for the medical professional, so that they do not stop enjoying their work, even when negative events occur—events that are inevitable in medicine. Such events are an occupational hazard, and they are traditionally perceived as a personal failure rather than valuable experience; they are often unpredictable and lead to unwarranted persecution. To minimize the consequences, healthcare professionals have the right to be well-prepared for all events that are part of their daily practice.

Yes, in the film, Yermakov is seen as an upstart; they try to "break him down" and fit him into the established system.

The continuing professional education reform proposes to stop pretending there is training where there isn't any, while simultaneously putting the comfort of most colleagues at risk. Teachers need to learn how to teach, medical professionals need to demonstrate that they know how to learn, and their supervisors need to organize this process for the benefit of the cause they serve.

Yermakov won because the result (a successful attack under impossible conditions) became an indisputable fact. To what extent was it guaranteed? Or was it just luck? I would like to know what became of this hero afterward, how he would have fit into subsequent events, and what he would be doing now?

What will become of our results? Will the ongoing reform help? Are fellow instructors ready to conduct simulation training and other forms of hands-on learning? How will this be perceived by the community? Will it lead to lives saved and professionals satisfied with their work after training?

Teaching troops instead of classrooms

Regarding the requirement of modern Russian legislation to ban exclusively remote continuing professional education, it is worth noting that this does not mean we now need to resume traditional lectures in classrooms. Of course not. We are talking about practical sessions that are safe and effective in a simulation-based training format. For practicing professionals, it is more useful, convenient, and comfortable to conduct these sessions not in a classroom — as is the case for those entering the profession or specialty for the first time — but directly in the workplace.

The advantages in identifying hidden threats lie precisely in the ward setting. The psychological aspects of overcoming the "fear of embarrassment" are addressed through work in small groups "just for our own people." We present the original concept of **"Teaching Troops"** — an adaptive model of in-situ simulation for medical personnel.

Unlike traditional off-site training cycles, the concept is based on mini-training sessions (ranging from 1 hour to 1 day) conducted directly in the workplace, which allows for the identification of hidden systemic threats and the integration of missing skills (e.g., communication or clinical reasoning for nurses) into routine practice, thereby transforming the passive lecture format into an active "clinical audit." This model is suitable for continuing education instructors seeking to overcome staff skepticism and the formalism of training curricula. The main focus is on participant safety, the use of algorithms in the form of cheat sheet posters, the analysis of real incidents using the "clinical detective" method, and in-situ simulations "without taking time off from work."

"Yermakov's Code" for the Medical Paratrooper Instructor

We propose for consideration the principles that, in our view, should help share responsibility for continuing professional education and prevent it from becoming yet another market for "buyers of educational certificates."

1. **Study as if tomorrow were the day of battle.** Don't settle for an "almost correct" answer. Practice until the skill becomes second nature, because at 3 a.m. during a bleeding emergency, a nurse won't have time to "recall the lecture."
2. **Move out of the classrooms and onto the "front lines."** Studies show that nurses' technical skills are higher after on-the-job training than in control groups, and this effect persists for 3 months. Simulation in a real-world environment allows you to practice exactly where the skills will be applied. This bridges the gap between "I can do it on a mannequin" and "I'll do it on a patient." Only on-site training allows you to identify process errors that aren't visible in a training center: faulty outlets, missing medications in the cabinet, or an inconvenient layout. In one study, in-situ simulation helped identify critical delays in defibrillation due to improperly stored electrodes — a risk that would never have been detected in a training center.
3. **Look for "gaps" in the system, not for someone to blame.** The goal of "Troops" training is to find systemic errors (an inconvenient cabinet, a poor protocol), not to "catch" a doctor or nurse in the act. Instructors are allies of the staff against complications, not enforcers for bureaucracy.
4. **Be prepared for resistance from the "generals."** If fellow instructors grumble that you're "wasting your time," it means you're on the right track. The system resists because change requires effort. Focus on the result — trainees satisfied with the training — rather than on the approval of bureaucratically minded staff.
5. **Results are the only judge.** Our proof is when a nurse says after "Troops": "I remembered our debrief yesterday and didn't make a mistake." One such instance is worth a thousand filled-out reports. Let's consciously collect such results as a community.
6. **Don't let the system "crush" your enthusiasm.** The main risk is becoming that very same weary colonel who "understands everything but does nothing." Seek out like-minded people. Build your own "crew" of active nurses and doctors. A lone wolf gets devoured; a group is feared. Join ROSOMED.

How to use this Code? Print it out for your team (that very "island of normality"). Let it be your internal oath. When things get tough or you feel like giving up and "just reading a lecture," remember Yermakov — beautiful formalism always leads to real losses.

Which point of this Code do you think will be the hardest to follow in your environment over the next year? For us, it's point 2, since it strikes at teachers' professional pride ("fear of making a mistake"), and point 6 — at human resources ("fatigue from the struggle"). How can we make it easier to comply with these points so they don't become "suicidal"? Unity!

Teamwork among educators. For example, a lecturer teams up with a facilitator or an active medical professional from the field. Their task is to explain "why" (physiology, standards), while their colleagues moderate and demonstrate "how." This relieves them of the fear of technical errors. And this isn't a loss of authority, but a partnership that commands respect.

To avoid burning out when the system tries to "grind you down," communicate with your colleagues—there are plenty of opportunities to do so. And celebrate the "small victories." Start a private list or chat where you'll post only good news: "Nurse N. found a labeling error on her own after the shift." In moments of low energy, this is your "fuel."

Conclusion

The system is inert, and it will try to return to a state of "calm formalism." But, just like in "Attack," the truth lies with those who see the real enemy (death, errors, complications, persecution, and burnout), not paper reports.

Select a "pilot" department for the first "assault" to achieve that very first result that will overcome your colleagues' skepticism.

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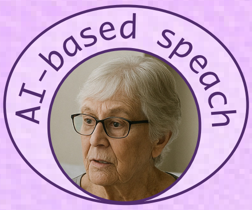
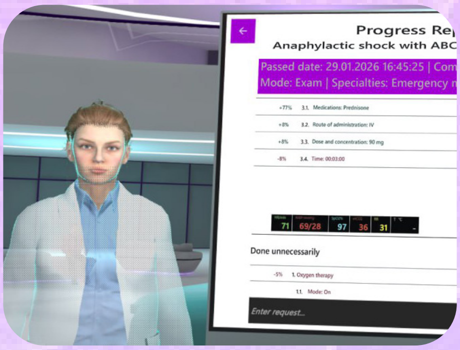
The authors would like to thank the AI assistant for their assistance in structuring the methodology and developing the terminology for the "Teaching Task Force" concept during the interactive design session.

DIMEDUS

Digital Medical Education Systems





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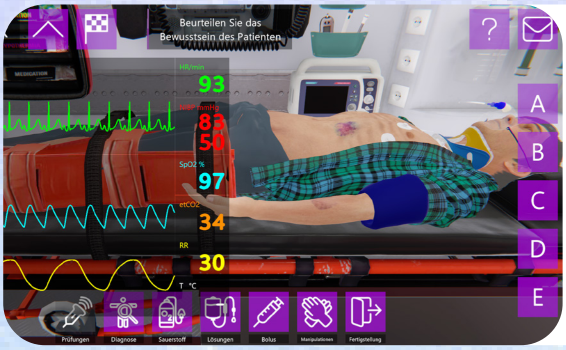

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